Climate Policy and International Tourism Arrivals to the Caribbean Region

by

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Author’s Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Increasingly the body of research shows that tourism is vulnerable to climate change. Tourism is also a non-negligible contributor to climate change, primarily through rapidly increasing air travel. Recently, a number of tourism destinations that are dependent on long-haul tourism have expressed concerns about the impact of climate policy (both implemented and proposed) on tourist mobility and arrivals to their countries. This thesis examines outcomes from a model which projects how climate mitigation policy could influence arrival numbers to the Caribbean region; an area projected to be disproportionately impacted by climate change. While impacts on this region are likely to be both physical as well as economical, mitigation policy restricting emissions from international aviation is likely to be the first wave of climate change effects felt. This policy, coupled with the fluctuation of global oil prices, may be a significant deterrent for travelers to the Caribbean. Different scenarios using likely mitigation policy costs on international flights and oil price fluctuations were modeled to understand how these tourism-dependent nations might fair with increases in travel cost due to conditions beyond their control. Both region-wide and destination specific results were examined showing that visitor numbers could decrease versus a business as usual scenario with climate policy and heightened oil prices, but not significantly until climate policy with deeper emission cuts and carbon prices higher than currently suggested are put in place. Result are not uniform across the region, and show that certain destinations are projected to be more vulnerable to climate mitigation policy than others. Recommendations focusing on both the aviation industry's inclusion in climate policy and those to aid the region's tourism sector are provided.

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List of Acronyms

AR4	Fourth Assessment Report
BAU	Business as Usual
CARICOM	Caribbean Community
CDM	Clean Development Mechanism
CH_4	Methane
CT	Carbon Tax
CO_2	Carbon Dioxide
$CO_{2\text{-}e}$	Carbon Dioxide Equivalent
EIA	Energy Information Administration
ETS	Emission Trading Scheme
EU	European Union
GCM	Global Climate Model
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
N	Nitrogen
NA	North America
NGO	Non-governmental Organization
SIDS	Small Island Developing State
SLR	Sea Level Rise
SRES	Special Report on Emission Scenarios
UK	United Kingdom
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNWTO	United Nations World Tourism Organization
US	United States
USSR	Union of Soviet Socialist Republics
WGIII	Working Group Three
WMO	World Meteorological Organization
WTTC	World Travel and Tourism Council

1.0 Introduction

The introductory chapter of this thesis will outline the research need and rationale for this study, the goals and objectives to be met, and the general structure that the thesis will take. The aim of this chapter is to provide a clear and concise overview of what will be presented in the chapters that follow.

1.1 Research Need and Rationale

The global travel and tourism sector has experienced continued growth over the past six decades with international arrivals increasing from an estimated 25 million in 1950 to 903 million in 2007 (United Nations World Tourism Organization [UNWTO], United Nations Environment Programme [UNEP], World Meteorological Organization [WMO], 2008). With 2007 international tourism receipts of US $850 billion, it is clear the sector is of major importance to the global economy (UNWTO, 2008; World Travel and Tourism Council [WTTC], 2009a). In fact, tourism export income is ranked as the fourth largest sector in the world, behind only fuel, chemicals and automotive parts (UNWTO, 2008). Much of this continued growth in international tourism has been possible because of technological progress in aviation (speed, safety, comfort) and the relative decline in the cost to fly (versus economic growth and wages). This 'revolution' in air travel has provided access to distant international destinations for millions of people in the last half of the 20th century (Becken & Hay, 2007; Janic, 1999). More recently, the introduction of the low cost air carrier has, among other things, allowed lower yield tourists to fly to their chosen destination (Becken & Hay, 2007). The increase in air travel has also allowed developing countries, particularly small island developing states (SIDS), to be more accessible as tourism destinations (Abeyratne, 1999).

Visiting a different climate, often a warm one, is considered a strong pull factor for many tourists who wish to relax for a time and to simply 'get away' (Aguiló, Alegre, & Sard, 2005). A large proportion of tourism to SIDS is this type of tourism, often termed 'sun, surf and sand' or 'sunlust' tourism; clearly indicating the significance of climate for these destinations (Hamilton, Maddison, & Tol, 2005; Uyarra et al., 2005). These destinations are, in large part due to this climate reliance, concerned about projections for a globally changing climate that is '*unequivocal'* (Intergovernmental Panel on Climate Change [IPCC], 2007c, p.5). The Fourth Assessment Report (AR4) of the IPCC projects rising sea levels due to the warming of oceans and glacial melting, pronounced and prolonged droughts, and increases in intensity of precipitation events as some of the impacts of a changing climate that will need to be adjusted to by many of these destinations (IPCC, 2007c). Recognition of the significance of a changing climate is becoming more widespread.

The tourism sector has recently acknowledged climate change as an important issue; specifically the two way relationship which exists between its activities and the changing climate (UNWTO, UNEP, & WMO, 2007; WMO & UNEP, 2004; WTTC, 2009a). More specifically, an understanding that activities undertaken by the tourism sector contribute to climate change through their emissions of greenhouse gases (GHG) while at the same time the sector is being (and will continue to be) impacted by the changing climate, has become clear. The global tourism sector is estimated to be responsible for approximately 5% of global CO_2 emissions (UNWTO et al., 2007) and since this information was released, calls from different global tourism organizations to curb the emissions the sector produces have been heard (UNWTO et al., 2007; WTTC, 2009a). A large portion (75%) of the emissions from tourism result from transportation and of that 75%, aviation contributes upwards of 40% (UNWTO et al., 2008). This large component of tourism emissions also has high projected growth rates, for example Boeing (2008) projects 5% annual growth in overall air traffic for 2007-2027, and therefore the difficulty of reducing emissions from both aviation and tourism as a whole, is clear. In fact, aviation is seeing emissions growth above all other modes of transportation (Europa, 2006; European Environment Agency, 2006) and even efficiency gains the industry may achieve, emissions from this transportation mode will still climb because of continued growth in passenger and freight kilometres (Gossling & Peeters, 2007).

Tourism dependent regions of the world, such as the Caribbean, rely heavily on air transport to bring visitors to their destinations (Caribbean Hotel Association [CHA] & Caribbean Tourism Organization [CTO], 2007; Abeyratne, 1999). Considering that in the Caribbean region, tourism contributes some 14.5% of GDP (WTTC, 2008) as well being responsible for 15.5% of total employment (WTTC, 2004), the importance of the sector and its main mode of transportation is clear. This dependency on tourism justifies concern over the potential impacts of climate change; both with regards to physical damage but also associated downturns in the economy. Impacts such as sea level rise, more intense hurricanes and increasing temperatures are likely to damage infrastructure and affect tourist arrival numbers thus affecting the livelihoods of millions. However, it is being acknowledged that these impacts are not likely to be the first challenges Caribbean tourism faces from climate change. Climate mitigation policy within countries that provide the vast majority of air arrivals to the Caribbean, coupled with an increasing understanding by travelers of aviation's contribution to climate change are likely to cause more immediate damage to the region (UNWTO et al., 2008) .

The threat of aviation being subject to requirements to reduce GHG emissions under climate policy is substantial. In 2012 all flights in and out of the European Union (EU) will be required to account for their emissions as a part of their emission trading scheme (ETS) (EU, 2009). Other areas, such as North America (NA) are also discussing similar policies (Ljunggren, 2008). With the inclusion of aviation into such climate policies coupled with rising global oil prices, the cost of traveling by air to a long-haul destination is likely to increase which may impact the ability or desire of some to travel to such destinations. This prospect is unsettling to Caribbean organizations and they note

> the immediate current threats are emerging as our major tourism markets seek to take urgent and decisive action to curb their own contributions to climate change. In so doing these developed nations risk curtailing the Caribbean region's efforts to develop its societies and economies through its participation in the global tourism industry
>
> (CHA & CTO, 2007, p. 2)

Despite the concern expressed by the Caribbean tourism stakeholders, the impact of proposed climate change mitigation policies remains unknown.

1.2 Goals and Objectives

In order to address the issues facing the Caribbean region as a consequence of climate change mitigation policy and future oil prices, the primary aim of this study is to examine how air travel tourist arrival[1] numbers could change for various Caribbean countries as a result of existing and proposed climate policy, which includes aviation. In order to determine how the Caribbean tourism sector will fare as a consequence of such impacts *four* main objectives have been derived:

i. To review the scientific literature and industry documents relating to climate change, tourism and aviation in order to determine recent trends in GHG emissions and projections of growth rates as well as the potential for climate policies to be implemented that would alter future GHG emissions from aviation;

ii. To examine destination level tourism data in order to determine the countries which provide the bulk of travelers to the Caribbean region (i.e. source markets);

iii. To model tourism data scenarios representative of future market conditions under climate change mitigation policy which regulates aviation emissions, coupled with future cost of oil forecasts, and the economic demand function, price elasticity, for the main source markets of the

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[1] From here forward, tourist arrivals indicates arrivals via air unless otherwise stated

Caribbean region in order to determine how arrival numbers to Caribbean destinations may alter; and

iv. To provide recommendations and strategies for the Caribbean countries in order to reduce their vulnerability to future climate policy that affects the cost of travel, and to contribute to a more sustainable tourism sector operating in a carbon-constrained world.

By undertaking such research, this thesis is the first known attempt to understand, in detail, how different climate policy scenarios coupled with future oil prices may impact tourist arrival numbers in the Caribbean region. The thesis will provide projections for likely outcomes of tourist arrivals (to 2020) given climate policies planned for implementation in 2012 (or proposed for implementation in similar time frames), as well as outcomes which are more likely as a consequence of policy implemented post-2020 (i.e. a 'serious' climate policy scenario[2]).

1.3 Structure of Thesis

This thesis has been divided into six chapters. The first chapter introduces the main problem and outlines the research goals and objectives. The literature chapter synthesizes existing academic and industry perspectives in the climate change, mitigation and tourism fields as they pertain to research on SIDS, namely those in the Caribbean. The urgency of climate policy to mitigate global GHGs and the contribution the global tourism sector has (particularly through air transportation) is the foundational literature for this study. Coupled with the knowledge that the tourism industry will also feel repercussions from climate change – both physical and economic, has lead to research to bring the two areas together. The focus on the Caribbean region is undertaken as it is an excellent example of a region which will be affected from two types of climate change impacts (physical and economic) and a region where concern over mitigation policy already exists.

Chapter three lays out specifics of how the projections for visitor arrival changes in the Caribbean region given climate policy implementation and volatile oil prices were undertaken. The chapter describes a model that details the process, inputs and data used to model the change in visitor

[2] The term 'serious' can be used interchangeably with stringent, high emission reduction, deep emission cuts in a short time frame and is meant to infer policy which would meet emission cuts discussed by the IPCC in a tight timeframe. The term has been used in academic literature (McKibbin & Wilcoxen, 2002; van den Bergh, 2009) as well as in the media (Lash, 2006).

arrival numbers for Caribbean countries as well as the rationale for which variables and values were used as inputs.

The model results are presented in chapter four both for the Caribbean region as well as for individual nations. Explanation of which input variables made the most difference to the results is also explored.

The discussion chapter further examines the impact that the change in arrivals may have on the region as well indicating the high and low vulnerability nations in the Caribbean region. To get a more comprehensive picture, not only are the highlighted results from chapter four discussed but other measures of tourism importance (i.e. percentage of national gross domestic product (GDP) accounted for by the sector) are also considered. A section on the 2008-2009 global economic crises is also included in order to understand better, how, at present, the region is faring with regards to visitation numbers under such a situation and how this might impact arrivals in the future.

Chapter six provides recommendations for the region and individual destinations about different strategies for reducing vulnerability to future climate policy. Recommendations are provided with regards to tourism plans as well as international climate policy and its inclusion of aviation. This chapter finishes with a synthesis of the findings, study limitations and also provides recommendations for further research in the field.

2.0 Review of Literature

The literature review is divided into three main sections. The first provides an overview of global climate change focusing on GHS emission scenarios, the mitigation response to reduce these emissions thus far, as well as likely mitigation policies in the near (i.e. 10 years) future to which the tourism sector will need to respond. The second section examines the climate change and tourism literature, focusing on the impacts likely to occur in SIDS. SIDS are often economically heavily reliant on climate-dependent tourism but, at the same time, are projected to be some of the most severely impacted by changing climate (Mimura et al., 2007). The third section looks at the Caribbean region specifically and examines tourism demand in this region as well as the impacts that are likely to be felt due to global climate change. The main focus of this section is on mitigation policy, as that will likely be the first significant impact of climate change to which the region will be subjected.

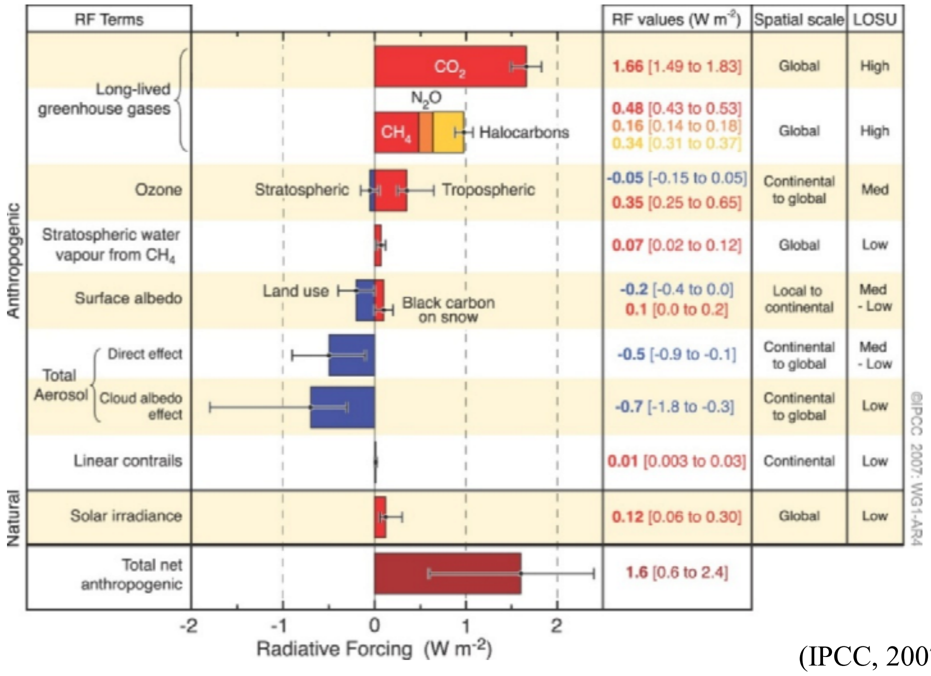
2.1 Global Climate Change

Historical shifts in climate are considered to be natural and have occurred over the millennia. The climate change of today, though, has been determined by the IPCC as very likely (>90%) to have been and will continue to be caused by anthropogenic sources and is occurring at an accelerated rate versus previous periods of warming (IPCC, 2007c). The most recent reports of the IPCC, those of AR4, describe the warming of the climate system as *unequivocal* (IPCC, 2007c). Given the heightened interest surrounding this reports' release, and the environment in general, as well as increased political attention to issues pertaining to the content of the report, it appears AR4 has done much to emphasize global climate change issues and concerns and to highlight the need to act promptly.

There are two main drivers of anthropogenic climate change – the largest is the increase in fossil fuel use, while land use changes are important but a secondary cause (IPCC, 2007c). As fossil fuels are burned GHGs, most notably carbon dioxide (CO_2) methane (CH_4) and nitrogen (N) , are released (IPCC, 2007c). CO_2 is the most important anthropogenic gas and emissions of it have risen from an average of 6.4 $GtCO_2$/year in the 1990s to an average of 7.2$GtCO_2$/year in the period of 2000-2005 (IPCC, 2007c). The total global atmospheric concentrations have increased from 280ppm in pre-industrial times to 379ppm[3] in 2005 (IPCC, 2007c). Concentrations of CH_4 have increased from 715ppb (pre- industrial) to levels of 1732ppb (early 1990s) (IPCC, 2007c) and although there has been a decline in CH_4 concentration since the 1990s, the aforementioned increases are *very likely* due to the increase in fossil fuel burning and land use changes (IPCC, 2007c). As of 2005, concentrations of both CO_2 and CH_4 were considered to "exceed by far the natural range of the last 650,000 years" (IPCC, 2007c, p.3).

The noted GHGs are detailed in *Figure 1* along with other contributors to total global radiative forcing[3], a measure used when discussing warming and cooling of the earth because it takes into consideration GHGs as well as other factors such as albedo and solar irradiance when detailing a warming or cooling trend (IPCC, 2007c). While both positive forcing, which is considered a source of warming, and negative forcing, a source of cooling, exist, *Figure 1* illustrates that presently positive forcing is stronger than negative. The IPCC has reported that since 1750, anthropogenic warming is +1.6 Wm-2 (Forster et al., 2007).

Figure 1 - Global Mean Radiative Forcing [4]



(IPCC, 2007c, p.4)

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[3] Terms such as radiative forcing, global warming potential, carbon dioxide and carbon dioxide equivalents are often used mistakenly as interchangeable. *Table 1* gives definitions of each term and how it will be used within this thesis.

[4] LOSU stands for Level of Scientific Understanding (IPCC, 2007a)

Table 1 - Terms of Measurement for Climate Change

Radiative Forcing (*RF*)	The change in the net, downward minus upward, irradiance (expressed in W m–2) at the tropopause due to a change in an external driver of climate change, such as, for example, a change in the concentration of carbon dioxide or the output of the Sun. (IPCC, 2007a, p.951)
Global Warming Potential (GWP)	An index, based upon radiative properties of well-mixed *greenhouse gases*, measuring the *radiative forcing* of a unit mass of a given well-mixed greenhouse gas in the present-day *atmosphere* integrated over a chosen time horizon, relative to that of *carbon dioxide*. (IPCC, 2007a, p.946)
Carbon Dioxide (*CO_2*)	A naturally occurring gas fixed by *photosynthesis* into organic matter. A by-product of fossil fuel combustion and *biomass* burning, it is also emitted from land-use changes and other industrial processes. It is the principal *anthropogenic greenhouse gas* that affects the Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured, thus having a Global Warming Potential of 1. (IPCC, 2007a, p.942)
Carbon Dioxide Equivalent (CO_{2-eq})	Is the concentration of carbon dioxide that would cause the same amount of radiative forcing as a given mixture of carbon dioxide and other greenhouse gases (IPCC, 2007a, p.945)

2.1.1 Emission Scenarios

Emissions of GHGs are considered the main cause of climate change and there is now much evidence to suggest that these emissions have grown substantially since before the industrial revolution. This is illustrated by the vast increase from 28.7 Gigatonnes of CO_2-eq to 49 CO_2-eq (70%) between 1970 and 2004 which was caused largely by increasing CO_2 emissions that grew about 80% during this same time period (Barker et al., 2007).

Given these increases, and in order understand where these emission levels may go in the future, the IPCC created the Special Report on Emission Scenarios (SRES) under which there are two different 'families' of emission scenarios. These scenarios project a wide range of emission paths based on different trends in human demographic, economic, political and technological futures (Schneider & Lane, 2006). The first two types of scenarios are classified as being a part of the 'A' family (i.e. A1 and A2 sub-scenarios). The A1 family portrays "very rapid economic growth, global population that peaks mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies" (IPCC, 2007e, p.7). The distinguishing factor of the sub-scenarios of A1 (that is A1F1, A1T and A1B) is that they each portray a different direction that technology for energy systems would take; fossil fuel, balanced, or predominately non-fossil fuel (IPCC, 2007e). The A2 scenario describes a 'heterogeneous' world focused on local identities where variables are regionally based and differ depending on regions and continents (IPCC, 2007e). The final two scenarios fall into the 'B' family: B1 is considered to have the lowest-emission outcome of the SRES scenarios and has some similarities to A1 (with regards to global population), but is considered to be geared towards a service and information society (IPCC, 2007e). B2 is focused at local and regional levels with an aim of environmental protection initiatives but also portrays a continually increasing global population (IPCC, 2007e). Each of the scenarios are considered equally as likely and are used to lay out potential emissions futures (*Figure 2* details each scenario more completely).

The SRES scenarios have an idea of what a future world could look like with different emission projections and have given more visibility to what climate change means and by this, an incentive to attempt and stop the climate from warming to a point where significant damages will occur. The different paths to take in order to achieve the reduction of emissions which will, at the very least slow down climate change, are vast and are detailed more in section *2.1.2.2*.

Figure 2 - SRES Storylines

Box SPM.1: The emission scenarios of the IPCC Special Report on Emission Scenarios (SRES)

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

An illustrative scenario was chosen for each of the six scenario groups A1B, A1FI, A1T, A2, B1 and B2. All should be considered equally sound.

The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.

This box summarizing the SRES scenarios is taken from the Third Assessment Report and has been subject to prior line by line approval by the Panel.

Source: (IPCC, 2007e, p.7)

2.1.1.1 Climate Change Observations and Projections

Much research has been undertaken to understand what has been occurring with the present global climate system, as well as historical trends and projections into the future. The IPCC has recorded existing climate change observations as well as projections for increased changes associated with further warming (IPCC, 2007c). Projections for warming to continue are strong, and the emission futures illustrate different degrees of change associated with different emission projections.

2.1.1.1.1 Observations of a Changing Climate

The IPCC AR4 lays out a list of observed changes in climate that range from temperature variations to sea level rise and precipitation variability – they are summarized below:

- *Warming of the global surface temperature*: Eleven of the 12 years between 1995-2006 were recorded to be amongst the 12 warmest on record. This is in addition to the linear warming trend for the 50 previous years (at 0.13˚C) which is almost twice what it was for the previous 100. Between 1850-1899 and 2001-2005 the total increase in temperature was recorded as 0.76˚C;

- *Atmospheric water vapour content*: Since (at least) the 1980's the atmospheric water vapour content has, on average, increased over both land and ocean and as well in the upper troposphere. This is linked to the amount of extra water vapour that warmer air is able to contain;

- *Global oceans*: Since 1961 the average temperature has increased to depths of 300m *and* the ocean has been absorbing more than 80% of the heat added to the climate system. Consequently, the sea water is expanding which contributes to a rise in sea level;

- *Glaciers and snow cover*: In the mountainous regions, both glaciers and snow cover have, on average, declined and the influx of water associated with the melt has also contributed to sea level rise;

- *Ice sheets*: Both the Greenland and Antarctica ice sheets have experienced some losses which contribute to sea level rise. For some of the outlet glaciers in these two areas, the flow speed (which drains ice from the glacier's interior) has increased;

- *Sea level rise*: On a global average, the sea rose 1.8mm/year from 1961-2003 and this rate increased to 3.1mm/year from 1993-2003. The total rise in the 20th century is estimated to be 0.17m;

- *Arctic temperatures*: The average temperature in the Arctic has increased at almost twice the rate of the global average in the past 100 years although temperatures in this region are known to vary by decade;

- *Arctic sea ice*: Based on satellite data from 1978 the average annual ice extent has shrunk by 2.7%/decade with larger decreases occurring during the summer months;

- *Precipitation*: Long term trends differ for different regions - some with more and some with less precipitation experienced. Heavy precipitation events have increased in frequency over most land areas which is consistent with increases in atmospheric water vapour;

- *Wind*: The mid-latitude westerly winds have, since the 1960's, strengthened in both hemispheres;

- *Drought*: Since the 1970's, longer and more intense droughts have been experienced over wider areas (particularly in the tropics and subtropics). This is a consequence, in part, of increased drying which is linked to higher temperatures and decreased precipitation as well as sea surface temperature changes, wind patterns and decreases in snowpack and snow cover;

- *Extreme temperatures*: Over the past 50 years, observations show that cold days, cold nights and frost have occurred less frequently while hot days, hot nights and heat waves occur more often;

- *Tropical cyclones*: Evidence since 1970 shows that the intensity of tropical cyclone activity in the North Atlantic has increased. There is great debate in academia about the trend line and the frequency of storms

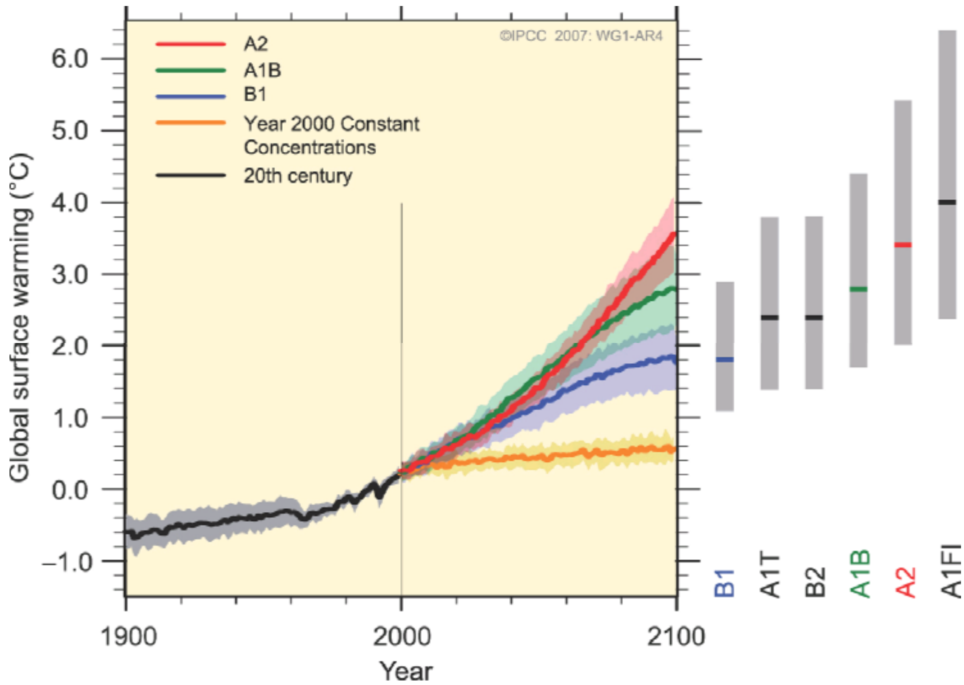
(IPCC, 2007c, p.5-9)

2.1.1.1.2 Climate Change Projections

Projections for future impacts under a changing climate and what they could mean have also been detailed. The IPCC presents many such projections that are based upon their SRES scenarios and global climate models (GCM). They are as follows:

- *Warming of the global surface temperature*: First, if the agents that contribute to radiative forcing were held constant at year 2000 levels, then the world would see a warming trend over the next two decades of 0.1˚C/decade (IPCC, 2007c). Alternatively, if emissions are in the range of one of the SRES scenarios then warming will be approximately double that, at 0.2˚C/decade (IPCC, 2007c). Each of the SRES scenarios offers estimates of changes in temperature (2090-2099 relative to 1980-1999) and their midpoints range from 1.8°C to 4°C (*Figure 3)*. Although these estimates were compiled for the 2007 release of the AR4, newer evidence suggests that, in fact, it is probable that the top end of this estimate, 4°C, is more realistic given likely emission trajectories over the next 30 years (Anderson & Bows, 2008). Warming is not projected to be uniform - the greatest increase in temperatures are expected over land and at high northern latitudes, while the smallest increases are likely to be felt over the Southern Ocean and parts of the North Atlantic;

Figure 3 - Range of Warming Estimates Based on SRES Scenarios



(IPCC, 2007c, p.14)

- *Sea level rise*: The SRES scenarios also offer a range of projections for sea level rise with the lower estimates being in the range of 0.18-0.38m and higher estimates at 0.26-0.59m for the same time scale as noted in the temperature ranges;

- *Atmospheric CO_2 concentrations*: Warming of climate is known to reduce the land and ocean uptake of the atmospheric CO_2. With trends of increasing climate warming projected there will be more anthropogenic emissions of CO_2 remaining in the atmosphere;

- *Global oceans*: A consequence of increasing atmospheric concentrations of CO_2 is ocean acidification; projections show a reduction of global ocean pH at 0.14-0.35 units over the 21st century which would be added to the reduction of 0.1 units seen since pre-industrial times;

- *Snow cover*: The projections are that snow cover will decrease in amount and with this, an increase in thaw depth over most permafrost regions is expected;

- *Sea ice*: In both the Arctic and Antarctic (and under every SRES scenario) sea ice is projected to shrink;

- *Extreme temperatures and precipitation events*: Projections are *very likely* that hot extremes, heat waves and heavy precipitation events will become increasingly more frequent;

- *Tropical cyclones*: Associated with the increasing tropical sea temperatures, it is *likely* that in the future, tropical cyclones will be more intense, have higher peak wind speeds and bring with them more heavy precipitation. Along with this, extra tropical storms are projected to track pole ward;

- *Meridional overturning circulation (MOC)*: Although the MOC of the Atlantic ocean is projected to *very likely* slow down during the 21st century, temperatures are still projected to rise in the Atlantic region due to the much larger warming associated with increases in GHGs

(IPCC, 2007c, pg.12-16)

2.1.2 Mitigation

Given the previously noted strong impact of GHGs, in particular CO_2 emissions on global climate change, it is clear that something needs to be done to reduce them if the accelerating rate of climate change is to be slowed and ultimately reversed. Working Group III (WGIII) of AR4 published stabilization scenarios that illustrate different temperatures and peak years related to different CO_2, CO_2-eq and radiative forcing values (*Figure 4).* Despite this, a threshold above which warming is considered dangerous is not given. The phrase 'dangerous' climate change was include in 1992 by the United Nations Framework Convention on Climate Change (UNFCCC) by way of a clause which called for GHG emissions to be stabilized so as to "prevent dangerous anthropogenic interference with the climate system" (UN, 1992, p.4). This was expanded on by providing a few parameters; namely a time scale which

> allow[s] ecosystems to adapt naturally to climate change; ensure[s] that food production [is] not threatened and enable[s] economic development to proceed in a sustainable manner
>
> (UN, 1992, p.4)

Since this publication, there have been many different interpretations of 'dangerous', some focusing on impacts, others on vulnerabilities or thresholds which would signify a dangerous level of climate change (Schneider & Lane, 2006). Despite the debates, it is generally accepted that the determination of what signifies dangerous climate change is a value judgment. Even the IPCC, which many thought would give an opinion on the topic has not and it has been noted that such a determination should be influenced by policy experts and scientists, but ultimately, it needs to be made by political leaders (Barker et al., 2007).

Figure 4 - Stabilization Scenarios

Table SPM.5: *Characteristics of post-TAR stabilization scenarios [Table TS 2, 3.10]*[a]

Category	Radiative forcing (W/m^2)	CO_2 concentration[c] (ppm)	CO_2-eq concentration[c] (ppm)	Global mean temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity[b), c)] (°C)	Peaking year for CO_2 emissions[d]	Change in global CO_2 emissions in 2050 (% of 2000 emissions)[d]	No. of assessed scenarios
I	2.5-3.0	350-400	445-490	2.0-2.4	2000-2015	-85 to -50	6
II	3.0-3.5	400-440	490-535	2.4-2.8	2000-2020	-60 to -30	18
III	3.5-4.0	440-485	535-590	2.8-3.2	2010-2030	-30 to +5	21
IV	4.0-5.0	485-570	590-710	3.2-4.0	2020-2060	+10 to +60	118
V	5.0-6.0	570-660	710-855	4.0-4.9	2050-2080	+25 to +85	9
VI	6.0-7.5	660-790	855-1130	4.9-6.1	2060-2090	+90 to +140	5
						Total	177

a) The understanding of the climate system response to radiative forcing as well as feedbacks is assessed in detail in the AR4 WGI Report. Feedbacks between the carbon cycle and climate change affect the required mitigation for a particular stabilization level of atmospheric carbon dioxide concentration. These feedbacks are expected to increase the fraction of anthropogenic emissions that remains in the atmosphere as the climate system warms. Therefore, the emission reductions to meet a particular stabilization level reported in the mitigation studies assessed here might be underestimated.

b) The best estimate of climate sensitivity is 3°C [WG 1 SPM].

c) Note that global mean temperature at equilibrium is different from expected global mean temperature at the time of stabilization of GHG concentrations due to the inertia of the climate system. For the majority of scenarios assessed, stabilisation of GHG concentrations occurs between 2100 and 2150.

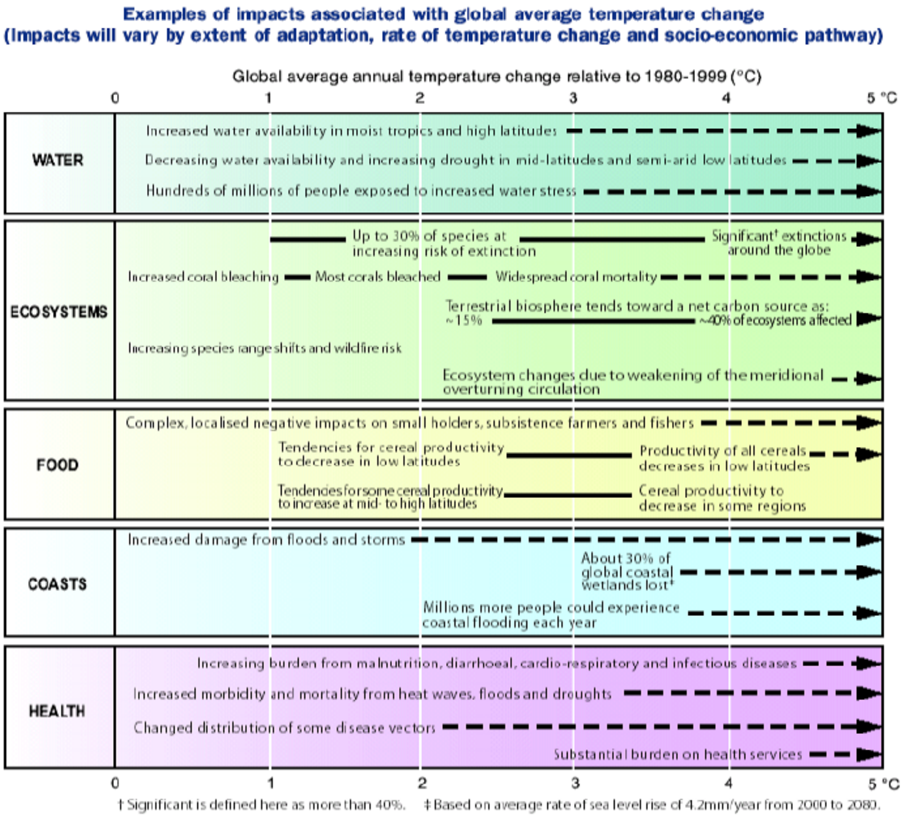
d) Ranges correspond to the 15th to 85th percentile of the post-TAR scenario distribution. CO_2 emissions are shown so multi-gas scenarios can be compared with CO_2-only scenarios.

Source: (IPCC, 2007b, p. 15)

Different groups and organizations have indicated what they believe to be dangerous anthropogenic warming and what should be done to curtail it. In particular, the EU has said that in order to avoid dangerous climate change, warming must be held below 2°C above levels in pre-industrial times (Barker, 2008b; Haag, 2007). This means concentrations of GHGs would have to be stabilized at levels of 450 to 550 ppm $CO_{2\text{-eq}}$ in 2050, (just slightly above current concentration levels which sit around 430ppm CO_2-eq) (Haag, 2007). The EU has committed to achieving this goal and therefore immediate mitigation needs to occur since their goal places concentrations in category I or II (*Figure 4*), meaning concentrations would have to peak, at the latest, in 2020 (Barker, 2008b). If emissions stay on the current trajectory though, they are more likely to reach the higher categories within *Figure 4* and the socio-economic parameters would most likely align with SRES scenarios such as A1F1 (Liverman, 2007).

The IPCC has detailed projections of what could happen to different parts of the climate system (i.e. ecosystems, hydrology) based on different temperature increases (see *Figure 5)*. The mitigation of the emissions responsible for the temperature increase is crucial if the impacts of climate change are to be avoided or at least slowed down. Regardless of what mitigation measures are taken, the warming that has already begun will continue because some of the earth's systems (i.e. oceans) have long uptake time scales that mean continued impacts will be felt in some form for more than a millennium to come (Barker et al., 2007)

Figure 5 - Climate Change Impacts at Differing Warming Scenarios



Source: (IPCC, 2007f, p.10)

2.1.2.1 Kyoto Protocol

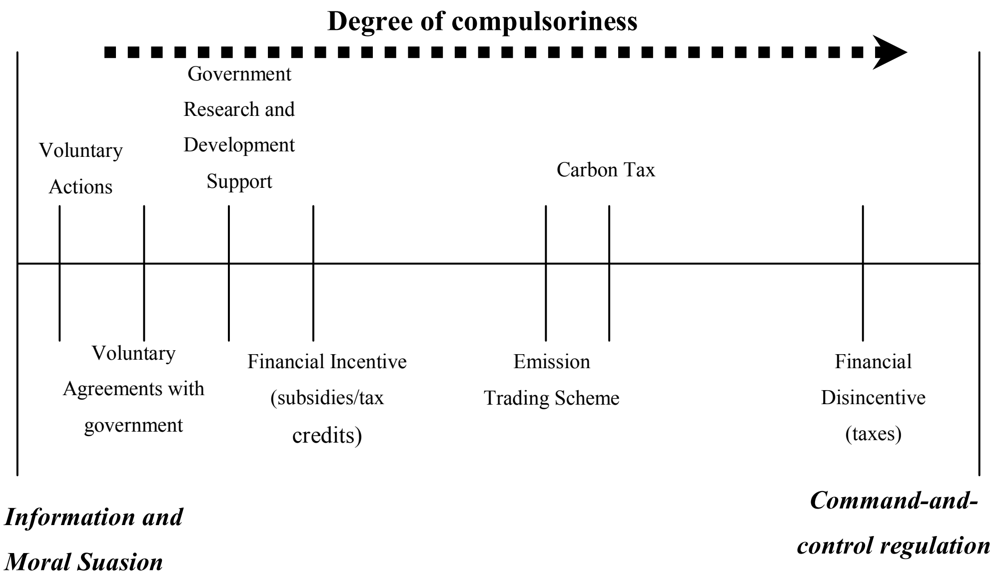
The Kyoto Protocol, an international treaty that came into force in 1994, is the main body through which global climate change mitigation potential has been discussed and implemented to date (Gupta et al., 2007). This treaty has the goal of reducing GHG emissions from the Annex I Parties (i.e. Australia, Japan, New Zealand, Canada, former Union of Soviet Socialist Republics [USSR] states, US, EU, Iceland, Norway) to 5% below 1990 levels (UNFCCC, 2008a). The Annex I parties are the counties considered to be the biggest emitters and are also the most capable of cutting emissions. The emissions covered by this treaty are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) (UNFCCC, 2008b). Through binding, country specific targets, Annex I signatories are required to reduce their emissions through innovative and advanced methods of mitigation (UNFCCC, 2008a). Thirty-seven industrialized countries and the EU have legally binding targets set for emission reductions required by 2012 (UNFCCC, 2008a). Although both Annex I and non-Annex I (the developing countries) may set targets for reduction, legally binding targets only exist for Annex I parties. More specifically, the targets are only legally binding for Annex I countries which have *ratified* the treaty – for example, the US has a set target but has not ratified the treaty and therefore is not legally accountable to this goal. Targets for Annex I parties range from -8% to +10% depending on the country and its situation; Canada has a target reduction of six percent below 1990 levels by the year 2012 and the EU a target of eight percent below (UNFCCC, 2008b). Many countries such as Canada and New Zealand will not likely meet their target while others, such as the EU appear to be on track to meet or even exceed their target reductions (Government of Canada, 2005; New Zealand Ministry for the Environment, 2006; UNFCCC, 2008c). The US has cited the lack of binding targets for countries such as China and India (MSNBC, 2009), which are quickly becoming some of the most significant GHG emitters, as the reason they are not participating in the treaty (Haag, 2007). Along with this, it has been suggested that some countries, such as Canada, which rely strongly on trade with the US are hindered in their ability to meet their own targets since their main trading partner and a world super power is no longer aiming to meet the targets of the Kyoto Protocol (Haag, 2007).

In December 2007, heads of state, scientists and observers came together in Bali, Indonesia in order to map out GHG mitigation for the second commitment period of Kyoto which, at this time, is not determined (Haag, 2007). Although there was much discussion at this meeting, very little was accomplished; only a road map for further discussion prior to the Copenhagen Meeting (Conference of the Parties [COP] 15) which will be held in late 2009 and agreement for consideration of increased national/international action on a number of items such as climate change and adaptation (Agarwala, 2008). The UNFCCC Convention subsidiary bodies held negotiation sessions, the Bonn Climate Change talks, in hopes to agree on further commitments before "the crucial conference", COP 15 (UNFCCC, 2009a; UNFCCC, 2009b). Since emissions trading is one of the main mechanisms laid out in the Kyoto Protocol, its continuation is thought likely be foundational in any post-Kyoto framework (Rosales, 2008). Transfer of technologies as well as development stimulus packages may be key to new agreements or treaties (Gupta et al., 2007). Some researchers also believe the way emissions allocation is done should change and that instead of focusing on country specific frameworks, looking at sectored targets may be more appropriate and yield more encouraging results (Gupta et al., 2007). This needs to be coupled with criteria necessary for a global agreement to work; some have noted such a policy should be comprehensive, employ an equitable strategy with realistic targets that is efficient and has an effective implementation process (Agarwala, 2008)

2.1.2.2 Mitigation policies

Although there are many different policy proposals for mitigating GHG emissions, two policies that are the focus of much discussion are the ETS as well as a Carbon Tax (CT). Jaccard, Nyboer & Sadownik (2002) portrays these and other potential policies along a continuum with compulsory policies occupying the far right side and voluntary ones on the far left. *Figure 6* depicts an adapted version of this spectrum including policies which are discussed in *Table 2* and the following sections.

Figure 6 - Continuum of Climate Policy Options



Source: Adapted from (Jaccard et al., 2002)

Table 2 - Climate Policy Options

Type of Policy	*Description*	*Reference*
Government Subsidies and Tax Credits	• if designed properly, are thought to be able to accelerate the development of low carbon technologies	(Chameides & Oppenheimer, 2007; Gupta et al., 2007)

	• may bypass barriers to market introduction for technologies • the cost tends to be higher than with many of the others discussed	
Regulations and Standards	• generally acknowledged as giving some certainty for environmental targets (if implemented and enforced rigorously) • not known to encourage low carbon technology development by big polluters • very few regulations which have the express intent to reduce emissions (often some reduction exists as a co-benefit from a regulation which has an initial goal of something different)	(Gupta et al., 2007)
Voluntary Agreements between Industry and Government	• attractive in the political arena and seem to raise stakeholder awareness • little evidence to show any significant emission reductions which are directly attributed to this method of mitigation	(Gupta et al., 2007)
Voluntary Actions	• tend to have limited success rates reducing emissions at both national and regional levels	(Gupta et al., 2007)
Government Research and Development Support	• can be used successfully as a mitigation policy to ensure that in the long term technologies which are low GHG emitters will be still available • dropped in favour after the oil crisis in the 1970's and has not been rejuvenated even in spite of pressure to meet emission reduction goals	(Gupta et al., 2007)
Information Instruments	• refers to requirements for disclosure in order that the general public has the ability to make more informed decisions about their purchases and perhaps reduce emissions via behavioural change	(Gupta et al., 2007)

	• evidence that this is instrumental in the achievement of emission reductions is limited	

2.1.2.2.1 Emission Trading Scheme (ETS)

The ETS policy (also known as the cap and trade system) is market- based and benefits from a flexible carbon price, set by the supply and the demand of the market, while at the same time allowing a limited number of permits to be issued so the emissions are capped by the government or overseeing authority, thus guaranteeing reduction in emissions by a set date (Chameides & Oppenheimer, 2007). In this system polluters must have permits at the end of the year for the emissions they release (National Round Table on the Environment and the Economy, 2007). There are numerous ways the permits can be distributed – by historical levels, grandfathering or one of the many types of auctioning (Jaccard et al., 2002) and polluters are also able to purchase or sell these same permits to others if their emissions are higher or lower than the amount for which they have permits (National Round Table on the Environment and the Economy, 2007). This system is credited with being attractive as there appears to be fewer political obstacles than other policy options (Bailey, 2007; Ekins & Barker, 2001; Jaccard et al., 2002).

From a business perspective the ETS is favoured because the market mechanism gives flexibility to companies to reduce their emissions in the least expensive way (Bailey, 2007). As well, the fact that there are models on which to base a new ETS (i.e. the sulphur dioxide policy in the US and the EU ETS) lends increasing support for this type of policy (Bailey, 2007).

Since emissions of GHG do not appear to impact the location from which they are released, the idea of an ETS is suitable for climate change mitigation as it would allow different sectors of the economy and different nations around the world to purchase or sell from other sectors or countries depending on whether they are intrinsically high or low emitters and thus emitters would not have to rely on local trading (Chameides & Oppenheimer, 2007). This type of reasoning requires caution though, lest a country or organization dismiss its obligations and emit more than its allowance, but is not punished in the end since it does it under a scheme where regulations do not exist globally.

2.1.2.2.2 Carbon Tax (CT)

As much as the ETS system is favoured by politicians, the CT tends to be preferred by economists and policy analysts (Bailey, 2007); they feel that the CT is the most efficient of the market approaches (Ekins & Barker, 2001) and it is considered cost effective as the marginal cost of emission control can be set with some assurance (Gupta et al., 2007). A CT would provide a set carbon price while having no set emission level allowing the price to set this limit, the reverse approach to an ETS (National Round Table on the Environment and the Economy, 2007). Another benefit of the CT system is that it is often seen as much easier to understand by general society but also less burdensome to create for policy makers and politicians (National Round Table on the Environment and the Economy, 2007). The CT does have drawbacks, perhaps the largest being the fact that the word 'tax' tends to be politically unpopular and is risky to the government that attempts to implement it. Take, for example, the proposed CT by the Liberal Party in Canada which ended up being a bad career move at the time, for the party's leader, Stephane Dion, and which is, in general, unpopular among the public (Meissner, 2009; O'Neill & Akin, 2008). Another drawback for the CT is that there is no current international precedent and therefore the process and results are relatively unknown (Bailey, 2007).

At a global level, the CT system could allow a staggered implementation phase in for developing countries – for example, when a country reaches a certain average income threshold the tax would be implemented (Bailey, 2007). A CT could also by-pass the controversial division of emission allowances across countries and industries (Bailey, 2007).

2.2 Tourism and Climate Change

As defined by the UNWTO, tourism is the

> activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes
>
> (UN, 1994, p.5)

It is one of the world's largest industries, accounting for 230 million jobs globally and close to 10% of global GDP in 2008 (WTTC, 2007; WTTC, 2009a) and in 2007 international tourist arrivals (from all transport sources) totalled 903 million (UNWTO, 2008). It is estimated that by 2020 the tourism industry will have grown to 1.6 billion international tourists, with the top destinations being Europe, East Asia and the Americas (UNWTO, 2001).

Being such a large sector brings with it issues of impacts on different aspects of society, the environment and the economy. Climate change, is one of the largest issues today, as noted in the 2007/08 *Human Development Report* that states "climate change may be the greatest challenge facing humanity at the start of the 21st century" (United Nations Development Programme [UNDP], 2007, p. 56). The acknowledgement of climate change as an economic and social issue facing the global population makes clear that all people, economies and countries are susceptible to climate change and that it is important to understand the implications projected , in this case, in particular on tourism (*Table 3* illustrates tourism specific impacts).

Table 3 - Climate Change Impacts and Their Significance for the Tourism Sector

Climate Change Impacts	***Impact on Tourism***	***References***
Observations:		
Warming of the Global Surface Temperature	Destinations potentially 'too hot'; new infrastructure needed to deal with different temperatures than visitor expect; change in demand due to changes in temperature at home	(Bueno et al., 2008; Scott, Gossling, & de Freitas, 2008; Simpson et al., 2008)
Atmospheric Water Vapour Content	No visible impact	
Global Oceans	Increasing temperature damages coral which is a key tourism market; thermo expansion which leads to rising water levels (see SLR)	(Bueno et al., 2008; Simpson et al., 2008)
Glaciers and Snow Cover	Leads to SLR; more difficulty for winter tourism activities such as skiing	(Scott, McBoyle, & Mills, 2003)
Ice Sheets	Linked to SLR	
Sea Level Rise (SLR)	Infrastructure damage (much tourism infrastructure in areas threatened by SLR is near the coast); infiltration of salt water into aquifers decreasing water availability (the tourism industry is a large consumer of water); loss of beaches	(Bueno et al., 2008; Simpson et al., 2008)
Arctic Temperatures; Arctic Sea Ice	Decline in species (i.e. Polar Bear) which rely on cold temperatures and sea ice to survive and which are a large tourist draw	(Dawson, Stewart, & Scott, 2009)
Precipitation	Considered a deterrent in many tourist destinations; a decline could lead to droughts (or in some cases better tourism conditions); vector-borne disease spread; decrease in water supply	(Bueno et al., 2008; de Freitas, 2003; Simpson et al., 2008)
Wind	No current known impact	

Drought	Water shortage; lack of greenery which is a draw for many tropical destinations	(Bueno et al., 2008)
Extreme Temperatures	See global surface temperature but is exacerbated	
Tropical Cyclones	Infrastructure damage; decline in tourist numbers during these times; insurance more difficult to get for tourism infrastructure	(Bueno et al., 2008; Simpson et al., 2008; Mills & Lecomte, 2007)
Projections:		
Warming of Global Surface Temperature	See Above	
Sea Level Rise	See Above	
Global Oceans	Acidification assists in the destruction of coral	(IPCC, 2007d)
Snow Cover	See Above	
Sea Ice	See Above	
Extreme Temps	See Above	
Tropical Cyclones	See Above	
MOC	No current known impact	

It is also critical to understand how contributions from different areas and industries across the world are further exacerbating the problem. Not only are tourist destinations grappling with what to do in the face of a changing climate (which has historically been one of their key resources), but also they are beginning to realise discussions about potential regulations aimed at decreasing GHG emissions are likely to impact the way they have traditionally done business. In the past, the tourism sector has done its best to describe its operations as neutral or even beneficial with regards to environmental impact (Gossling et al., 2005) but with the Djerba Declaration in 2003 beginning discussions of the two way relationship between climate change and tourism and the 2007 Davos Declaration emphasizing the importance of this understanding, a new light has been shed on the impacts that an industry as large as tourism clearly has on the environment – specifically on climate change (UNWTO, 2003; UNWTO et al., 2007). In the past, operators have been looked at as reasonably environmentally acceptable even though they alter many parts of the environment (i.e. change of land cover, use of energy) (Gossling, 2002a). More recently, and largely due to international pressures on tourism and the knowledge by industry leaders that the industry must embrace and reassess its environmental impact, events such as the

Pacific Asia Travel Association (PATA) Chief Executive Officer (CEO) challenge have arisen. These give industry leaders in the tourism field the opportunity to discuss how to help combat tourism's contribution to climate change (PATA, 2008).

2.2.1 The Tourism Sector

The tourism sector has become an important element of many countries' economies and a staple in the economy for a large number of developing states (UNWTO, 2008). Tourism is a dynamic system since destinations around the world compete for tourists who determine the supply and demand for the sector (Hamilton et al., 2005). Putting a definitive box around the components which make up tourism is a challenge as it is considered a composite sector which incorporates parts of other sectors such as transportation, retail and accommodation (Becken & Hay, 2007). It is also a unique type of export sector, since the consumers actually travel in order to consume the goods and services provided (Becken & Hay, 2007; Crouch, 1996).

The tourism sector has been looked upon as an area of opportunity for advancement by many developing countries (Becken & Hay, 2007). Part of the reason for this focus is that the expenditure from visitors on accommodations, transport, shopping etc. creates employment and development possibilities, causing the industry to become a mainstay in the economies of many developing countries (UNWTO, 2007b). For many SIDS, the development of transportation infrastructure (in large part for aviation) is a necessary precursor to their successful tourism development (Prideaux, 2000). However, economic leakage is an important consideration, and is generally regarded as detrimental to developing countries which rely on tourism (Becken & Hay, 2007). This concept illustrates the amount of money spent by tourists which does not stay in the local economy (UNEP, 2002). Often a large percentage of the tourism revenue 'leaks' away by going directly to the state or foreign investors rather than being cycled through the local economy. Leakage is especially of concern for developing countries which have large amounts of foreign investment (Becken & Hay, 2007), and, even though the tourism income often leaves the destination, the infrastructure (i.e. airports, roads etc.) which is necessary for that sector to succeed tends to be financed though taxes paid for by local residents (Becken & Hay, 2007). Concern over environmental degradation, relatively lower wages for those employed by the industry and seasonal unemployment have arisen in the debate over whether tourism should be promoted as a development strategy (Gossling, Hall & Scott, 2009). The tourism industry can therefore pose both challenges and opportunities for developing countries as tourism is also able to utilize resources (i.e. remote beaches) for economic gain which would otherwise hold only minimal economic value (Gossling, 2002b). Critical to a better understanding of these issues is long-term monitoring of the impact of tourism within developing countries; this has historically been poorly done (Gossling et al., 2009).

The travel to and from destinations tends to be done by one of four modes; surface transportation (including personal vehicles), air, rail or water. In 2007, just under half of tourist arrivals were passengers arriving via air (47%) while the remaining 53% arrived via surface transport (road – 42%, rail – 4%, water – 7%) (UNWTO, 2008). Historically, and even as recently as 2001, road transport was the predominant source of travel with 52% of arrivals (Becken and Hay, 2007). However, in the past few years, the aviation industry has seen continual growth, surpassing growth rates of both road and water transport (Johnson & Cottingham, 2008; UNWTO, 2008). This quick growth can be largely attributed to the introduction of low-cost airlines and consequently improved accessibility of more people worldwide – especially low-yield tourists (Becken & Hay, 2007). Although the growth in air travel is projected to continue into the future, and with it international travel (WTTC, 2008), given the current global economic crisis and the fluctuating oil prices, these projections may need to be viewed with increased uncertainty.

2.2.2 The Relationship between Climate Change and Tourism

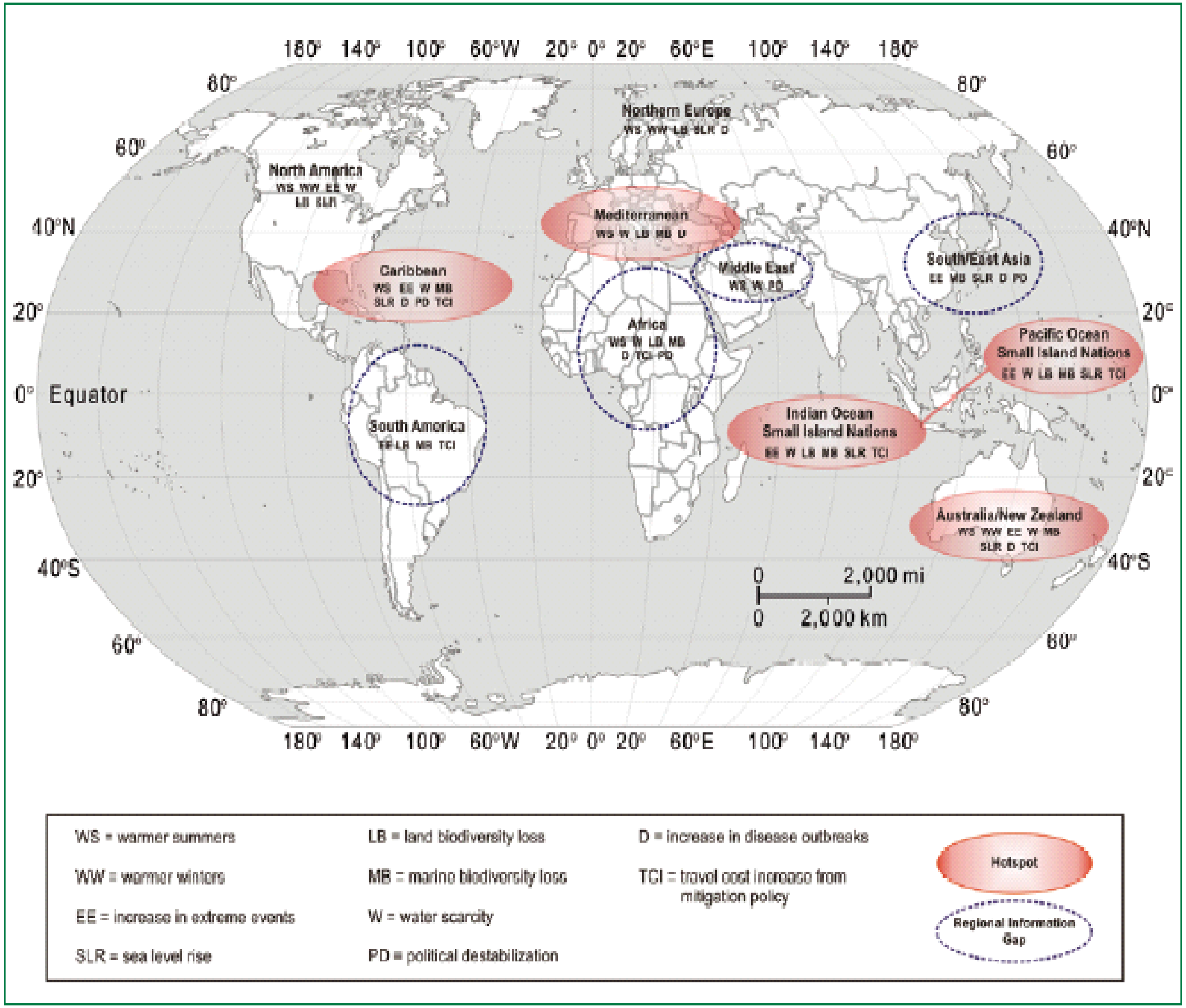
The UNWTO as well as the WMO and the WTTC have recently acknowledged that those who rely on the tourism industry for income are likely both to be impacted by, but also contribute to, climate change (UNWTO et al., 2007; WTTC, 2009a). The changing climate is expected to impact the industry in at least three different ways; physically, economically and socially (Buultjens, White, & Willacy, 2007) as well as both directly and indirectly (UNWTO et al., 2008). As the industry grows and the feedback between climate change and tourism becomes more obvious, the issue is likely to gain saliency for tourists given the changing climate in their home location and their exposure, through media and word of mouth, to the changes occurring in destinations.

Due to the many sectors and activities that contribute to tourism, it has been estimated that 5% of global CO_2 emissions can be attributed to this sector (UNWTO et al., 2007). Of these tourism emissions, transportation contributes 75%, of which aviation has been reported to contribute upwards of 40% (UNWTO et al., 2008) Unfortunately though, the growth in the aviation sector is at odds with emerging global climate policy, for example, aviation emissions grew by 25 per cent between 1990-2000 during which time global emissions only grew by 13 per cent (Johnson & Cottingham, 2008). This means that given the forecast of a doubling in air travel over the next 10 years, unless policies are implemented to reduce demand or emissions impact, air travel will be a serious counterweight to global mitigation targets (Johnson & Cottingham, 2008). Despite this challenge, international aviation is not included under any international climate policy that sets GHG targets, although some regions (i.e. the EU) are looking to include emissions from international flights in their own climate mitigation strategies (EU, 2009; UNWTO et al., 2008). At present, international aviation is also exempted from many taxes and levies (such as fuel and value added taxes [VAT]) that impact domestic aviation and most other forms of transportation (Gossling, Peeters, & Scott, 2008).

Transport, though, is just one of the three main facets of tourism – accommodation and tourist activities are the other two and have themselves been reported to be responsible for 21% and 3%, respectively, of total tourism GHG emissions (UNWTO et al., 2008). Although estimations exist for all three components, there has been significantly more research done analyzing emissions from transport and accommodations; leaving a research gap in the analysis of emissions from different tourist activities (Becken, Simmons, & Frampton, 2003). Combined, these emissions are of significant concern for the global community as well as an issue that needs to be addressed by the tourism sector which will be vulnerable to a push for the reduction in GHG emissions from aviation. Destinations, which are considered 'long-haul' (i.e. Caribbean, Australia, New Zealand), are already expressing concern over the potential for such policies because of a fear their visitor numbers will decline as a consequence (CHA & CTO, 2007; Forsyth, Dwyer, & Spurr, 2007).

Some of these same regions which are concerned are also considered to be by far more vulnerable to climate change as a whole (i.e. from physical impact) – they are considered vulnerable 'hot spots' for climate change (see *Figure 7*). The fact that these vulnerable hot spots fall largely in developing areas of the world means they will not only experience more severe impacts over the years but due to their situation will often be less able to deal with the impacts created, increasing the magnitude of concern. A further injustice is that these same countries are often the ones which contribute very little (proportionally) of the GHGs which are the largest contributing factor to climate change (Mimura et al., 2007). On the other hand, the developed countries are, in general, likely to experience the smaller magnitude impacts and have a much better ability to adapt to a changing climate but are the ones that have, by way of development and industrialization, contributed significantly to the climate change problem.

Figure 7 - Climate Change Vulnerable Hot Spots



Source: (UNWTO et al., 2008)

Of developing countries, SIDS are thought to be among the most vulnerable to the impacts of climate change as they are susceptible to many of the impacts projected by the IPCC, most notably sea level rise and changes in precipitation and/or storm intensity and frequency (Bueno et al., 2008). Many of these same SIDS are dependent on climate sensitive economic activities (in many cases, tourism) which rely on a stable, aesthetically pleasing climate in order to prosper (Uyarra et al., 2005). Compounding these factors is the overall size of the country and limited accessibility due to their remoteness and location leave them at a great disadvantage in both an economic and social sense (Abeyratne, 1999).

2.3 Tourism in the Caribbean

The Caribbean is a region made up of many SIDS and is one of the vulnerable climate change hot spots illustrated in *Figure 7*. Part of the reason it is considered so vulnerable to climate change is because of the nature of the SIDS; many are small, low-lying islands– e.g. Barbados (Belle & Bramwell, 2005) - while other have a lack of adaptive capacity - e.g. Haiti (Pelling & Uitto, 2001). As well, on the whole, the region is heavily dependent on international, long-haul visitors who frequent most islands (Lewsey, Cid, & Kruse, 2004) for an escape from the cold of the western hemisphere winter or simply for a relaxing break (Aguiló et al., 2005) making it susceptible to changes in visitor demand.

2.3.1 Background

Tourism in the Caribbean has existed for centuries, some even say Christopher Columbus was the first tourist in 1492 (Daye, Chambers, & Roberts, 2008), but in reality, the mass tourism market which now dominates Caribbean tourism began in the mid twentieth century (Sahay, Robinson, & Cashin, 2006). The specific timing of development differed slightly depending on the island, but, in general, this growth in the sector was stimulated by two main events:

1. The independence that was achieved by many Caribbean countries as they moved from being a colony to gaining political autonomy, and
2. The introduction of the inexpensive jet plane, providing easy access to the islands from NA and the EU

(Duval, 2004, p.10-11)

Islands such as the Cayman's and Anguilla have become prosperous by relying on tourism as their economic mainstay and others, seeing this example, look to this sector as the key to their own development (Duval & Wilkinson, 2004). As noted, tourism provides an increased revenue source for many of the islands, but, with the increase in expenditures on infrastructure necessary for tourism activities, many of the islands have become increasingly debt laden (Sahay, 2006). In fact, 14 Caribbean countries are among the 30 most indebted emerging market economies in the world (Sahay, 2006). The reliance on tourism as an economic staple exacerbates this issue as the governments purchase many imported products (such as petroleum) and therefore suffer as market prices fluctuate (Sahay et al., 2006). Also, as tourism demand changes due to external shocks of some sort so then does the income from the sector and consequently the national economy has to spend more or less.

Because the Caribbean nations are reliant on a certain subset of nations for the majority of their tourist arrivals, primarily North American and European countries (Daye et al., 2008), concerns and trends in those societies, economies and political structures cause much of the shifting of travel demand to the Caribbean. This demand is influenced by many different parameters – few, if any, are controllable by the Caribbean nations they impact. Many such parameters have been documented as determinants which alter tourism in general (and these can be broadly applied to the Caribbean region); those often noted are:

- Oil prices (See *Figure 10,* pg. 50)
- Exchange Rates
- Global Interest Rates
- Global Economic Volatility (growth and volume)
- Natural Disasters (i.e. hurricanes, tsunamis, earthquakes)
- International Political Events (i.e. security risks, terrorism, disease outbreaks, political unrest)

(Duval, 2004; Sahay, 2006; UNWTO, 2006; Witt & Witt, 1995)

Exogenous shocks have been known to cause temporary fluctuations in demand for the region in the past (i.e. 9/11 terrorist attacks in the United States, SARS outbreak, 1970's oil crisis) and so should be taken into consideration as the industry strives for continued growth.

2.3.2 Climate Change Impacts

The Caribbean region is projected to experience two distinctly different types of impacts from the warming climate; physical, such as those which are directly or indirectly related to sea level rise, temperature change etc, and mitigation, those mainly economic which are a consequence of GHG reduction policies.

2.3.2.1 Physical Impacts

The physical impacts of climate change are attributed to a variety of changes in climatic factors. Temperature change is predicted, based on a baseline scenario, to rise in the region 1.5°C by 2025 (Lewsey et al., 2004). Temperature predictions can be further divided into sea surface and surface air –

both of which are thought to be on a gradual, general warming trend (Lal, Harasawa, & Takahashi, 2002). *Table 4* depicts the range of projected air temperature changes over time periods up to 2100.

Table 4 - IPCC Projections of Temperature and Precipitation Variability in the Caribbean Relative to the 1961-1990 Period

	Air Temperature (°C)	**Precipitation (%)**
2010-2039	0.48 to 1.06	-14.2 to 13.7
2040-2069	0.79 to 2.45	-36.3 to 34.2
2070-2099	0.94 to 4.16	-49.3 to 28.9

Adapted from (Mimura et al., 2007)

Changes in precipitation for the Caribbean region are projected to be quite varied, even to the point that the direction of change (an overall increase or decrease) is unclear (Mimura et al., 2007). *Table 4* illustrates these wide projection ranges. Also, and as a consequence of the precipitation variability, changes to soil moisture will occur (Lewsey et al., 2004).

There is continuing uncertainty regarding the correlation between hurricane frequency, intensity and location with climate change; the question is whether climate change will have an impact on any or all of these hurricane traits (Gualdi, Scoccimarro, & Navarra, 2008; Mann & Emanuel, 2006; Shepherd & Knuston, 2007; Vecchi, Swanson, & Soden, 2008). Questions about the effects on frequency and average speed are common (Gualdi et al., 2008; Landsea et al., 2006; Mann & Emanuel, 2006). Some predictions do suggest though that the frequency and intensity are somewhat sensitive to the increased heating in the oceans and will therefore increase with sea temperatures rises (Landsea et al., 2006) – others, though, predict significant decreases in intensity (Vecchi et al., 2008; Lugo, 2000). If those who believe the intensity will increase are correct, then there would be more seasons like 2004 which was a season of strong hurricanes and consequently significant damages (Lugo, 2000; Tompkins, 2005; Vecchi et al., 2008).

Damages from sea level rise (SLR) are likely to be significant and considering sea level is projected to rise by 2100, relative to 1980-1999 levels, by between 0.18-0.59m (IPCC, 2007c) although, regional climatic and tectonic action may alter this (Mimura et al., 2007) and so the Caribbean region may experience a higher or lower level of impact. Since AR4 some researchers have found that this estimate could be low and SLR could instead rise between 0.54 to 0.77m by 2100 (Horton et al., 20098).

In a recent report on SLR in developing countries, the World Bank reported the possibility that, given continued GHG emissions and associated climate warming, that SLR would be closer to 1m-3m by the end of the century (Dasgupta et al., 2007). This study also revealed particularly disturbing news for many Caribbean countries. Of the 84 developing nations that are included in this study, the Bahamas is consistently noted to be one of the most impacted by rising sea levels (Dasgupta et al., 2007). Impacts of SLR were measured on the basis of impact on land area (where the Bahamas is considered the most in danger with 12% of its area susceptible), on population, on GDP, on urban extent, on agricultural extent and on wetlands (Dasgupta et al., 2007). In each of these considerations, the Caribbean region was represented in the top 10 most susceptible by at least three different countries; the Bahamas ranked in the top 10 in each category and Suriname and Guyana were also noted several times (Dasgupta et al., 2007). One of the most troubling statistics is that with regards to land area susceptible to SLR, the Caribbean region incorporates five of the top ten countries (Dasgupta et al., 2007). Considering the reliance tourism has on land, especially coastal areas, this is likely to pose significant economical and social problems for the region.

Threats to coastal areas are significant in the Caribbean, considering that more than half the population in the region resides within 1.5km from a shoreline (Mimura et al., 2007) where climate impacts, which increase erosion or cause storm surges and other destruction of costal landscape, will be intensified. This same area is where much of the tourism infrastructure exists (i.e. international airports, roads, beaches, capital cities; not to mention resorts and golf courses) (Mimura et al., 2007). The changing climate has the ability to increase coastal erosion which would result in lost property and dislocation of people, and to increase and intensify storm surges which would see saltwater intrusion into local water sources making crucial fresh water scarce for both the population of the islands and the tourism industry in general (Tompkins, 2005).

All of the projected impacts are bound to have detrimental effects on the tourism industry not only from a physical damage side but also from a traveler's perspective. For example, a warm and sunny climate has always been a pull factor for the Caribbean tourism industry but the possibility of temperatures becoming too warm for comfort needs to be considered as an impact of the changing climate. A study done by Scott *et al.* (2008) illustrated that for vacations to beach-centered destinations (like many of the Caribbean countries), there is an optimal temperature of 27˚C. Therefore, this region could see a decline in visitors due to surface air temperatures that are considered too warm. On top of this, the origin country which supplies many of the tourists to warm weather destinations may also see a warming, therefore decreasing the desire of citizens to travel elsewhere to experience the climate which they want (Scott, McBoyle, & Schwartzentruber, 2004). Another climate variable that influences travel behaviour, often in conjunction with humidity and temperature, is precipitation (de Freitas, 2003; Gossling et al., 2006). Although the overall trend of precipitation is uncertain, the fact remains that precipitation is often among the top factors noted with regards to influencing visitor comfort (Gossling et al., 2006) and if in fact precipitation levels increase, then there are likely to be negative repercussions felt by the sector regarding visitor satisfaction and ultimately choice of travel destination. The projected spread of vector-borne diseases, like malaria, due to the increased temperature may also cause problems for tourism (Uyarra et al., 2005). It seems reasonable that people might be less willing to visit a location where they are at risk of contracting such a disease and instead will substitute another comparable place which does not carry this possibility. The current and projected increase in sea surface temperature is likely to trigger more frequent coral bleaching events (McWilliams et al., 2005; Donner, Knuston, & Oppenheimer, 2007) which, in turn, is likely to cause a decrease in tourism particularly for those areas in the Caribbean which rely largely on dive tourism (Economic Commission for Latin America and the Caribbean, 2007). Avid snorkel and scuba divers are less likely to travel a distance and pay money to see a reef that has been seriously damaged.

The industry is projected not only to be impacted by changing visitor tendencies, as a result of climate change, but also by some direct effects on infrastructure and business costs. The projections for sea level rise, storm surges and potential increased intensity of extreme events leave the infrastructure and beaches of the industry (a large part of which are located within 1.5km of the coast) at extreme risk of damage (Lewsey et al., 2004; Belle & Bramwell, 2005). The potential for rising insurance premiums, or in some cases uninsurable properties, will be a serious problem for industry as it tries to sustain a livelihood located in an area identified to be particularly vulnerable to climate change (Belle & Bramwell, 2005; Mills & Lecomte, 2007; UNWTO et al., 2008). Areas which are storm prone in Florida are already uninsurable and that trend is likely to continue southwards as storms damage the same area time and again (Mills & Lecomte, 2007). Given the high level of dependence on tourism infrastructure in high risk areas, a widespread inability to get insurance would be devastating for the Caribbean region. A final direct impact on the tourism industry is water stress. Many islands in the Caribbean are already considered to be under stress from lack of water but with the modeled projected changes in climate this could be a region-wide phenomenon (Mimura et al., 2007). With this fact in mind and looking specifically at tourism, water stress will impose significant restrictions to the way of doing business. The tourism industry relies on water for many obvious things such as cooking, cleaning, guest room usage not to mention keeping the grounds green and aesthetically pleasing and the many pools and hot tubs full. Water stress would impose significant restrictions to the current way of doing business (Belle & Bramwell, 2005).

2.3.2.2 Impacts of Climate Mitigation Policy

Although it is anticipated that the Caribbean will be affected by the direct and indirect impacts of climate change, the most imminent economic threat for many of these countries comes from mitigation policies which tourist origin countries have already implemented or are in the process of implementing and an increasing traveler's awareness of the impact aviation has on climate change (UNWTO et al., 2008). It may be years until major sea level rise, temperature or precipitation change are damaging to the point of altering visitor arrival numbers but if mitigation policies that increase the cost of vacations are implemented and/or people stop traveling long distances by air because they feel guilty about their contribution to climate change, the destination countries will begin to feel economic strain as a consequence almost immediately. This vulnerability is caused by heavy economic investment in the tourism industry and its reliance on air transport to Caribbean islands[6]. In fact it has been said that development of SIDS tourism and air travel are *inextricably* linked (Abeyratne, 1999).

Coupled with this is the concept of an increasing awareness by travelers of their contribution to climate change when they fly, sometimes termed 'traveler's guilt', which has been intensified by media and published pieces condemning air travel because of its disproportionate impact on climate change (i.e. "Flying on holiday 'a sin', says Bishop" (Barrow, 2006) and "Oz Fears Jet-flight Guilt" (Bartlett, 2007)).

Given the understanding of these challenges, many of the countries that are home to visitors of the Caribbean are looking at trying to reduce emissions from aviation by including them in ETS', CT's and/or adding fuel surcharges to tickets. Presumably this extra cost will be passed on to passengers (as has happened with baggage charges and fuel surcharges when fuel costs rose in mid 2008 (ETN, 2008; Steinmetz, 2008a). This will increase ticket prices and, if the additional cost is significant, alter which destinations are most popular versus those which may see a reduction in visitor arrivals.

As noted above, the Caribbean relies on limited source markets, mainly North America and parts of Europe, both of which are long haul destinations, and both of which generally require air transportation to pursue vacations in the region**.** As such, the Caribbean destinations are at the mercy of

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[6] For the year 2007 there were 22.7 million tourist arrivals (via air) to the Caribbean region and 19.2 million cruise passenger visits (Griffith, 2008). It is also important to remember that many cruise passengers fly to their port of call before they board their cruise vessel.

the decisions made in these origin countries regarding whether to include or exclude aviation in the climate mitigation policies that are implemented. The CTO has expressed concern over this and noted that since they are likely to be impacted by such policies, they believe they should play a role in their creation (CHA & CTO, 2007)

What appears to be the most viable climate mitigation policy from the perspective of the origin countries is that of an ETS. Although there are other types of mitigation policy (see section *2.1.2.2*) given that the EU already has an ETS in place and there are discussions of a NA one (Ljunggren, 2008) as well as talk of a global ETS for international bunker fuel emissions[7] (Barker, 2008a), it seems that this is the policy which is most likely to be considered.

Coupled with an ETS as the predominant climate change mitigation policy, there is also likely to be some sort of a fuel surcharge or tax implemented by the aviation industry if oil prices rise; such a situation was instigated in the summer of 2008 on some flights worldwide (Steinmetz, 2008b).

2.3.2.2.1 European Union ETS

The EU ETS came into existence in 2005 and has quickly become a benchmark for other countries' ETS plans and even for a future global ETS (European Commission, 2007). In fact, to provide a solid building block for future international ETS' is one of the goals set out by the Commission which created the EU ETS (European Commission, 2007).

The EU ETS is divided into different trading periods; the first being 2005-2007, the second 2008-2012 and the third period, beginning in 2013 will go until 2020 (Europa, 2008). Each trading period distributes allowances (some free, some auctioned) which cover a percentage of emissions that are determined from a baseline year (Europa, 2008). For the first trading period, 95% of the allowance were allocated free of charge to the installations (companies and organizations) which required them, but the second trading period saw only 90% allocated for free (Europa, 2008). The remainder of emissions beneath the cap (5% and 10%, respectively) were then auctioned (Europa, 2009). The idea is that eventually (for most industries by 2020) "[the] auctioning of allowances is to be the rule rather than the exception" therefore increasing the allowances to be auctioned on the market (Europa, 2009)

During the first trading period, only installations in the energy, iron and steel processing, mineral, wood pulp and paper and board industries were regulated under the ETS (Europa, 2008). Even

[7] Bunker fuel emissions are "emissions from international aviation and maritime transport" (UNFCCC, 2009c)

given what seems like a somewhat small number of installations, these industries actually account for 40% of overall GHG emissions in the EU and about 50% of total CO_2 emissions (European Commission, 2007). The second trading period (2008-2012) introduced nitrous oxide emissions into trading (European Commission, 2007) and future trading periods are to include aviation, both domestic and international flights, which will be required to participate starting January 1, 2012 (EurActiv, 2008).

The ETS itself is based on emission allowances. In the simplest of terms, one allowance allows one tonne of CO_2 (or some amount of another GHG that has an equivalent global warming potential during a specified period) to be emitted (European Commission, 2007; Europa, 2008). Because the EU is made up of sovereign nations, the allocation of allowances is currently done on a national basis to cover the different trading periods (European Commission, 2007). The 'cap' on allowances is what stimulates the need for a marketplace where companies which are below their specified emission allocation can sell the extra allowances to others which emit more than their allocated amount (European Commission, 2007). The buying and selling of allowances can take place directly between the two installations or via a broker or any other type of market intermediary (European Commission, 2007). On top of purchasing extra allowances from within the EU ETS, members may purchase credits from the Kyoto Protocol's Clean Development Mechanism (CDM) and Joint Implementation (JI) in order to have their level of emissions covered by permits (European Commission, 2007). The credits from these two programs (the JI's permits are called emission reduction units and the CDM's permits are called certified emission reductions) are considered to be equal to EU emission allowances with the exception of those from the land use, land use change and forestry category (Europa, 2008). One goal of both the CDM and JI credits is to help to facilitate technology transfer to developing countries and economies in transition which is aided by its inclusion in the EU ETS' plan (European Commission, 2007). Although incorporating CDM and JI within this trading system can be beneficial, there are also concerns, largely, that by allowing purchases of credits which are not designated within the ETS allowances, overall reductions may not occur because an installation could simply purchase credits from a region where emissions are not regulated (Agarwala, 2008).

Because regulation is so important, enforcement in this ETS is critical. The ETS is set up so that at the end of each year the installations must hand over enough allowances to cover their emission units (European Commission, 2007). These allowances are then erased so they cannot be used again; any extra allowances may be sold or saved for future emissions (European Commission, 2007). If the installations do not have enough allowances to cover their emissions then they are required to pay a fine of €40 (for the first period) and €100 (for the second period starting in 2008) for each tonne of CO_2

which they emit above their allowance (European Commission, 2007). There are also other deterrents such as public notice of those installations which do not meet their targets and the fact that these installations need to purchase allowances during the next year to cover the previous year's shortfall (European Commission, 2007). These enforcement measures occur at the EU level but some countries have other specific dissuasive procedures (European Commission, 2007).

Including Aviation

In the past, international aviation has been reported to account for 2% of global CO_2 emission (IPCC, 1999). These are dated estimates and the European Commission's decision to include aviation in its ETS is based on the fact that the growth pattern for the industry, which is such that by 2050 emissions contributed by aviation will grow to (at least) 5% of global totals, will likely compromise objectives to meet reduction targets and reversing efforts made by other industries (EurActiv, 2008). The decision originally was to include domestic flights under the ETS as of 2011 and international flights would have a year longer before they were required to abide by the rules of the cap and trade system (European Commission, 2007). This plan was revised after significant concerns of unfair competition between EU and non-EU airlines that might arise during the year when only domestic aviation was regulated (EurActiv, 2008). As well there were some who believed a staggered approach would undermine the overall environmental impact of the ETS (EurActiv, 2008). Revisions were made and the ultimate decision states that as of January 1, 2012 flights into or out of any airport in the EU will be regulated under the EU ETS, meaning they will have to participate in the use of emission allowances (EurActiv, 2008).

The inclusion of aviation in this multi-sector ETS is considered a major step to curb GHG emissions from international aviation since, to date, there is no accountability measure of their impact on anthropogenic climate change (EurActiv, 2008). Although the Kyoto Protocol, in Article 2, recognizes that the aviation sector needs to be addressed with regards to its contribution to GHG emissions, it does not directly address international flights but instead leaves that to the International Civil Aviation Organization (ICAO) (UN, 1998) which to date has not implemented strategy that would lead to reduction in GHGs in the foreseeable future (European Federation for Transport and Environment, 2008b; Gossling & Peeters, 2007)

The decision to include aviation operators in the ETS was strongly opposed by some, to the point that the United States (US) threatened trade sanctions if the EU went forward and required foreign airlines to participate in the ETS (EurActiv, 2008). The US went to ICAO's General Assembly and was granted a resolution which required any country implementing a market-based measure to first obtain the consent of those third parties which operated in their airspace (EurActiv, 2008). Had this resolution been legally enforceable, it would have prevented the EU ETS from moving forward with the inclusion of international aviation in their plan (EurActiv, 2008). The EU counteracted the US sanction with a formal reservation which in essence rendered the US's resolution non-binding (EurActiv, 2008). The European Regions Airline Association has also gone on record criticizing the legislation for the extra financial burden on the industry and the Air Transport Association of America has noted that it believes such a move is in conflict with the Chicago Convention and predicts legal challenges because of it (EurActiv, 2008).

Not all industry and political discussion about aviation's inclusion in the ETS is negative. In fact, Air France has said it welcomes the ETS and believes it is the best way to reduce the impact air travel has on climate change (EurActiv, 2008). The unit head for the EU's Commission on clean air and transport noted that the inclusion is not the worst outcome for the industry but also stressed the need for agreements on a global level that would reduce any negative competition outcomes for airlines impacted (EurActiv, 2008). The EU Environment Commissioner remained fairly neutral on the issue, responding to the criticisms of the legality of the inclusion by noting that it was in line with international rules and his belief that there will not be any legal challenges as the critics know they could not win (EurActiv, 2008).

Aside from these comments, some organisations believe that this inclusion is not enough or that its rules are not laid out in the proper form to actually achieve its goal. The Director General of the International Air Transport Association (IATA) noted that the inclusion of aviation in the EU's ETS needs to be only one part of a much larger plan to reduce emissions from air travel, noting that the reduction in number of air traffic control centres would centralize the routes and reduce time in the air therefore reducing emissions (EurActiv, 2008). Others, such as a United Kingdom (UK) Liberal Democrat MEP, said that this inclusion cannot do what it needs alone and suggests the aviation sector be no longer excluded from fuel taxes nor from the VAT. The UK's Institute for Public Policy Research also noted that all the inclusion will do, if the airlines are handed emission credits for free, is pass on costs to passengers and airlines will subsequently make a profit (EurActiv, 2008).

Although other options were considered for restricting GHGs from aviation, the decision for inclusion in the ETS remains solid, despite continued debate (EurActiv, 2008). Aviation will be included through a phased-in approach. For the first year (2012) there will be allowances allocated to operators that amount to 97% of average aviation GHGs emitted between 2004-2006 and for the period of 2013-2020 this cap will be lowered to 95% (EurActiv, 2008). At the beginning, only 15% of the allowances would be auctioned, the rest being distributed for free (EurActiv, 2008). If installations emit above the cap they will be required to purchase extra allowances from other installations to make up their shortfall.

2.3.2.2.2 North American ETS

There is currently no national or continental ETS in effect within North America although the possibility of one is increasing since the new President of the United States, Barack Obama laid out a plan for a cap and trade system in his election platform. This proposal was aimed at emission reduction of 80% below 1990 levels by 2050 (Obama for America, 2008). The cause seems to be moving forward illustrated by the fact that at the end of March 2009 a draft bill for discussion entitled the American Clean Energy and Security Act of 2009 was tabled in the US House of Representatives, suggesting that the cap and trade policy could be implemented in the near future (Markey & Waxman, 2009). Coupled with these actions is interest from the Canadian federal government in working with the United States to create a North American cap and trade system (Ljunggren, 2008). What this ETS will look like, timelines, and emission reduction targets and baselines, is at present uncertain in part due to the lack of specific discussion of a cap and trade system during President Obama's visit to Canada in February 2009 (Colvin & Mason, 2009)

There are some other regional initiatives in North America. The first of these is the Western Climate Initiative (WCI) which was created in February 2007 by governors of five western states: California, Oregon, New Mexico, Arizona and Washington (WCI, 2009b). This initiative has grown and now includes 11 jurisdictions on both sides of the border – from a Canadian perspective, Manitoba, British Columbia, Quebec and Ontario are the four provinces which have signed on to the initiative (WCI, 2009b). The goal of the WCI is to "identify, evaluate, and implement collective and cooperative ways to reduce greenhouse gases in the region, focusing on a market-based cap-and-trade system"(WCI, 2009b) . The WCI has laid out a an initial implementation time frame of 2012-2020 which is to be divided into three year compliance periods (McMillan LLP, 2008). This program will cap not only CO_2 emissions but all six GHG which are covered by the Kyoto Protocol (McMillan LLP, 2008). Similar to the EU ETS, the first compliance period will cover large industrial process emitters along with large electrical generators and industrial fuel burners, and issue allowances to polluters by their state or provincial jurisdiction (McMillan LLP, 2008). Smaller emitters will be required to comply in subsequent periods (McMillan LLP, 2008). It does not appear that aviation operators will be held to the ETS requirements when the WCI is implemented, although there is reference to aviation fuel in several tables of GHG emissions (WCI, 2009a).

Another ETS which exists within North America is the Regional Greenhouse Gas Initiative (RGGI) which began in 2003 when the governors from Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont began discussing the potential for a cap and trade system that would address emissions from power plants in their jurisdictions (RGGI, 2009b). In 2005, seven of the original states announced an agreement and in 2007 the other three originals signed on to the regional cap and trade system for power plants which came into force on January 1, 2009 (RGGI, 2009b). The goal of the RGGI is to cap CO_2 emissions from the power generating sector and, by 2018, to see an overall reduction of 10% (RGGI, 2009a). Ideally, this system can be expanded for regulation of other industries and ultimately lays the groundwork for a national system (The Northeast Regional Greenhouse Gas Coalition, 2005).

A Canadian national system appears to be not as likely as a combined North American one but some provinces are trying to speed up the process of regulating GHGs. In June 2008, Dalton McGuinty and Jean Charest, Premiers of Ontario and Quebec, respectively, formally stated they will work together to establish a carbon trading program to reduce GHG emissions (CBC, 2008). The plan, which is speculated to be similar to the WCI in its implementation, aims to reduce emissions in the two provinces to 1990 levels although, at this point, there is no time frame set and no indication that aviation will be regulated by it (CBC, 2008).

2.3.3 The Price of Oil and Tourist Mobility

To date, the international aviation industry is largely exempt from fuel taxes and many other forms of taxation, such as the VAT , which other transportation industries are required to pay (Gossling et al., 2008; IPCC, 1999; Johnson & Cottingham, 2008). In the EU this fuel exemption is slowly changing; EU parliament voted in 2006 to tax fuel for flights which originated in any of the 25 member states (European Federation for Transport and Environment, 2006). Currently though, only the Netherlands have implemented this tax (Simpson et al., 2008).

In North America, domestic flights are subject to federal and provincial/state fuel taxes but international flights are exempted from these (Air Transport Association of Canada, 2005; Air Transport Association, 2009; Department of Finance, 2001). While there are a variety of rules and taxes being discussed for international aviation, none are actually reducing emissions from the industry's GHGs.

It has been suggested that as the cost of fuel rises, airlines would only have three options in order to stop their profit margins from decreasing: cost reductions in sales and marketing, in non-fuel and labour, or pass the increased cost along to the passengers – the later has proven to be true. Fuel surcharges were added by many major airlines, equating to airlines passing on costs to passengers (Sorensen, 2008). Airlines even began charging for a second piece of checked luggage in an attempt to keep weight onboard the plane down and consequently to burn less fuel. The reason for these surcharges is that for an average air carrier when oil prices are in the range they have been for the past year, fuel cost makes up 1/3 of their operating costs (Viscotchi, 2006) and in order to compensate for a hike in the price of fuel they need to increase the price of tickets or else see a decrease in their profit margin. This evidence suggests that when fuel surcharges make vacations more expensive for tourists who arrive via air, the tourism sector may feel economic slowdown from decreased visitors who can no longer afford the vacation.

2.4 Chapter Summary

This chapter has discussed the topic of global climate change and emission scenarios and how they will impact the tourism industry and vice versa. It has also highlighted the Caribbean region, a strongly tourism dependent part of the world, and the impacts that it will feel, both physical and economical, from different climate change effects. Detailed discussion of the EU and potential NA ETS and the inclusion of international aviation under one or both was undertaken in order to understand the urgency of the problem for aviation dependent long-haul tourism destinations, of which the Caribbean region is a significant section. The following chapters seek to understand more completely how such policy may impact regional tourism as well as destination specific visitor arrivals.

3.0 Methods

The objectives of this research are to determine how climate policy and future oil prices may work together with tourism demand to alter arrival numbers to the Caribbean region. It does not attempt to model tourism demand due to all economic factors, such as exchange rates, income, relative prices between origin and destination, expenditure or market dummy variables (such as political turmoil or special sporting events) or transportation which are often done in studies that aim to estimate an elasticity value (Sinclair & Stabler, 1997). Rather, by using the price elasticity's resulting from such studies, the modeling done for this thesis examines how two important factors affecting international tourism (i.e. mitigation policy by way of an ETS and future global oil prices) could, in the next 15, affect the cost of air travel and thus tourist arrivals. Climate change mitigation policy coupled with peak oil - dubbed 'the twin threats' - in the airline industry (Johnson & Cottingham, 2008) are rising in importance and both can be expected to have impacts on arrival numbers (i.e. cost of air travel, cost of accommodation due to energy price) in the next couple of decades.

3.1 Scope

Because the Caribbean region is large and has many different definitions, the study area is restricted to the 20 Caribbean Community (CARICOM) members and associates, plus three other large island nations which are popular tourist destinations; Cuba, the Dominican Republic and Puerto Rico. *Figure 8* shows the location of these countries and *Table 5* gives some basic information on them.

Figure 8 - Map of the Caribbean

Source: (The Atlas of Canada, 2009)

Table 5 - Basic Data for Caribbean Countries

Country	*Land Area (km^2)* *(CIA, 2009b)*	*Population ('000) in 2008* *(CIA, 2009b)*	*GDP (million USD) Official Exchange Rate at most recent date used when available – if not, GDP PPP used* *(CIA, 2009b)*	*International Tourist Arrivals* *(UNWTO, 2007a)*
Anguilla*	102	14,108	108.9	62,084
Antigua and Barbuda	442.6	84,522	1,089	238,804
The Bahamas	13,940	307,451	6,586	1,608,153
Barbados	431	281,968	3,739	547,534
Belize	22,966	301,270	1,274	236,537
Bermuda*	53.3	66,536	4,500	269,591
British Virgin Islands*	153	24,041	839.7	337,000
Cayman Islands*	262	47,862	1,939	167,802
Cuba**	110,860	11,423,952	45,580	2,319,334
Dominica	754	72,514	3114	79,257
Dominican Republic**	48,730	9,507,133	36,400	3,690,692
Grenada	344	90,343	590	98,548
Guyana	214,970	770,794	1,039	116,596
Haiti	27,750	8,924,553	5,435	112,267
Jamaica	10,991	2,804,332	11,210	1,478,663

Montserrat	102	5,079	29	9,690
Puerto Rico**	9,790	3,958,128	72,610	3,685,900
St. Kitts and Nevis	261	39,817	527	127,000
St. Lucia	616	159,585	958	317,939
St. Vincent and the Grenadines	389	118,432	559	95,506
Suriname	163,270	475,996	2,404	160,022
Trinidad and Tobago	5,128	1,047,366	20,700	463,191
Turks and Caicos Islands*	430	22,353	216	200,000

* Associate Members of CARICOM

**Non-CARICOM Members

3.2 Model Parameters

In order to calculate the changing number of tourist arrivals for the different Caribbean countries, there were many parameters to be determined in order to provide final inputs for the model.

3.2.1 Arrival Data

The visitor arrival data used is UNWTO tourism arrivals data (UNWTO, 2007a). Although other measures of tourism demand (such as tourism expenditure or the number of nights at a given location) are sometimes considered more robust, the majority of tourism-related studies use arrivals data because it is often more reliable and readily available (Crouch & Shaw, 1992). This data depicts arrivals from air travel which is the most important form of transportation for Caribbean tourist arrivals. While cruise arrival numbers are also significant, air travel tourists are more critical since they stay on the island and contribute substantially to the economy, as opposed to those who visit the island off of a cruise ship, are ashore for only a few hours and spend most of their money onboard their vessels (Bryan, 2007). The year used as the base for most arrivals calculations is 2005 as it provides the most recent and complete data set available. Although there are a few gaps and/or inconsistencies in the data set, (*Table 6)* it is important to note that this data is from the global tourism organization which is respected for its collection of tourism data and to which countries report their own statistics, giving it the best possible ability to provide accurate, reliable and comparable information.

Table 6 - Inconsistencies in Data

Country	***Data Unavailable for One or More Years, Therefore Growth Rate Based on Available Data***	***Arrivals to One or More Airports in Country Missing***
British Virgin Islands	✓	
Dominican Republic		✓
Guyana		✓

There was also data available for the countries from the CTO. For the most part, this data was available from 2002-2006 and although most of the reported arrival numbers were similar, or exactly the same as the UNWTO data, one - Puerto Rico – was considerably different. The UNWTO arrival data was reported in non-resident tourist arrivals whereas the data for the CTO is reported in non-resident hotel registrations; leading to the discrepancy in the arrival numbers.

For all other countries used in the study, data was reported as non-resident tourist arrivals. For this reason, and also because one aim of this research is to create a model that could be used in other parts of the world (where CTO data is not applicable but UNWTO data is) the UNWTO dataset was used. Therefore, the data used was reported in "*arrival of non-resident tourists at national borders, by country of residence"* and the arrivals were divided up by origin region (e.g. North America, EU) and then further by specific country. The data was assumed to account for arrivals from air only (therefore excluding cruise ship visitors) and comparison to air arrivals data from the CTO for 2002 to 2006, confirmed this.

Arrivals data was used to determine an average growth rate of total tourism arrivals for each Caribbean country studied, and also to decide which origin countries would be modeled for each destination. This was undertaken by calculating the average change in rate of arrival from *total* arrival numbers for the years 2000-2005.

The 2006 CTO data was used to determine whether the growth rates calculated from the UNWTO five year trend were accurate. Sixty-six (or 14 of the 21 countries) of the projections based on the

UNWTO growth rate were within 10% of the numbers reported to the CTO for 2006. These UNWTO growth rates were the business as usual (BAU) growth rates used in the model. One other country fell just above this at 11% difference, another did not have CTO data available for the 2006 date so no comparison could be done. The remaining five countries appeared to have large discrepancies between reported and projected arrivals in 2006.

Firstly, as noted above, the Puerto Rican data from the UNWTO was different than the CTO data and so, to evaluate the accuracy of the Puerto Rican data, the researched compared growth rates in the two data sets. It was shown that the growth rates of the two different data sets are very similar; the 2002-2006 growth rate from the CTO data is 3.78% and the 2000-2005 growth rate from the UNWTO data is 2.31%. The discrepancy between the two is possibly due to the different date ranges. The remaining four countries, with greater than 10% differences in the actual (CTO 2006) versus projected (based on UNWTO) numbers, are those which displayed overly positive (i.e. 25.35%) or negative (i.e. -12.99%) growth rates from the UNWTO data, growth rates that are quite likely unsustainable. Both the Cayman Islands and Grenada were hit by Hurricane Ivan in 2004 which caused a downturn in their tourist arrivals for 2004 and on into 2005. Although arrivals seem to have increased again in both nations, when the initial growth rate was calculated from the UNWTO data the decline in visitation dominated the averaged arrival growth over the five year period. Because of this drastic downturn which has skewed the growth rates of these two countries, the 2005 data which was heavily impacted by the hurricane and determined a growth rate based on 2000-2004 data was eliminated. The fourth country to be looked at is Suriname, which displayed a very large growth rate (a five year average of 25.35%) that appears to be due to the introduction of direct flights between Paramaribo (Suriname) and Amsterdam (the Netherlands) in 2004. This new flight seems to have allowed former Surinamese residents to visit friends and family more easily (Caribbean Update, 2004). Bermuda, displayed a negative growth rate, in large part due to a decline in visitation during 2002; perhaps a signal of the unwillingness of Americans (who make up 75% of arrivals) to travel so soon after the September 11 terrorism attack tragedy.

Having examined the anomaly data and determined which destination countries to use, the next step was to select origin countries which are *significant* contributors to arrivals for each respective destination country. A threshold of 60 percent of total arrivals was chosen for the number of arrivals to model, largely because it was determined that if all arrivals were to be modeled it would become increasingly complex and above this threshold, the modeling would be done for non-EU/NA markets which have no current prospects for climate mitigation policy.

The actual model inputted different climate policy variables only for origin countries which were located within either the EU or NA, the locations where an ETS is likely to be implemented. For some Caribbean countries that have a large number of arrivals from other areas (i.e. other Caribbean or South American countries) the percentage of arrivals that was modeled under the ETS parameters was below the 60% threshold (*Table 7*). If those origins were not from the EU or NA then the country appears to already be at an advantage because their visitors will not be impacted by the extra cost associated with an ETS.

Table 7 - Percentage of Total Arrivals from EU or NA Countries

Destination	***% of Total Arrivals from 'Significant' EU or NA Origin Country***
Anguilla	67.22%
Antigua and Barbuda	66%
The Bahamas	85.82%
The Barbados	70%
Belize	67.71%
Bermuda	75.67
British Virgin Islands	64%
Cayman Islands	70.82
Cuba	50%
Dominica	31%
Dominican Republic	62%
Grenada	46%
Guyana	65%
Haiti	68.30%
Jamaica	71.66%
Puerto Rico	76.74%
St. Lucia	62%
St. Vincent and the Grenadines	43%
Suriname	58.39
Trinidad and Tobago	61%

Turks and Caicos	77.40%

In order to get a destination-wide arrival change number for 2020 the remaining arrivals (after those from the EU and NA were deduced) were assumed to change at the BAU rate of growth/decline and were therefore altered accordingly to get a projection for arrival numbers in 2020. These were then added to the arrivals projected for 2020 in all significant origin countries which were modeled with ETS and oil price increases to get a total destination change in arrivals number.

3.2.2 Climate Policy

Climate policy, in this study, is referred to as an ETS which includes aviation that will begin impacting arrival numbers as of 2012. For the purpose of this study, two different potential climate policy scenarios were modeled:

1. climate policy implemented as is proposed in the EU coupled with an identical plan in NA, and
2. a 'serious' climate policy plan implemented in both the EU and NA which has deeper emission cuts and carbon costs that are considered representative of the social cost of carbon.

3.2.3 Emissions per Trip

Determining the CO_2 emissions for a round trip flight from a given origin to a certain destination was calculated in January, 2009, using the ICAO online emission calculator (*http://www2.icao.int/public/cfmapps/carbonoffset/carbon_calculator.cfm)*. The data for each trip is listed in *Annex B.* Since it was necessary to find an online calculator which matched the EU ETS's current criterion of only accounting for CO_2 impacts, ICAO's was the logical choice (Department of Transport, 2007). Alternative calculations would include an uplift factor (ranging from 1.7% to 5.1% depending on timescale considered), which considers non-CO_2 climate impacts and emissions at higher altitudes (Forster, Shine, & Stuber, 2006; IPCC, 1999; Sausen et al., 2005). Although the inclusion of this factor will give a more accurate picture of the total climate impacts aviation has, it is excluded since the actual climate policy regulating the industry does not consider it.

3.2.4 Cost of Carbon

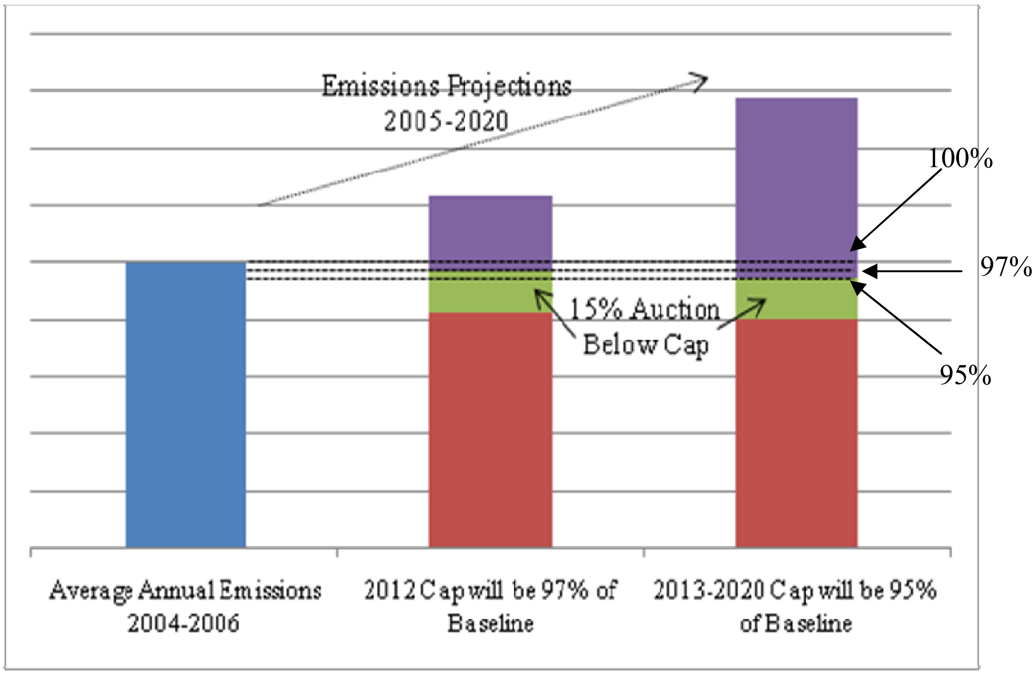
Forecasts for what carbon emission allowances will cost in the future are speculative and there is a great degree of variability in estimates (see *Table 8)*.

Table 8 - Cost of Carbon Estimates

Price of Carbon	Details	Source
13€/tonne	2009 price on the European Climate Exchange	(European Climate Exchange, 2009)
25€/tonne	2008-2012 forecast price	(JP Morgan, 2007)
30€/tonne	post-2012 forecast price	(JP Morgan, 2007)
40€/tonne	2021-2030	(JP Morgan, 2007)
50€/tonne	2031-2050	(JP Morgan, 2007)
27€/tonne	2008-2012 forecast *if* developed nation has a successor treaty to Kyoto and the EU adopts a 30% target	(Fortis, 2008)
48€/tonne	2008-2012 forecast *if* no new treaty	(Fortis, 2008)
35€/tonne	2008-2012	(Deutsche Bank, 2008; Societe Generale, 2008)
30-35€/tonne	2008-2012	(UBS, 2008)
$20/tonne	2015 (on CO2-eq)	(National Round Table on the Environment and the Economy, 2007)
$200/tonne	2020 (on CO2-eq)	(National Round Table on the Environment and the Economy, 2007)

The range of these values is great and projections continually change. It is important to note that some of the higher estimates (i.e. the 2020 projection from the National Roundtable on Environment and Economy) may not be looking specifically at what will occur, but more likely at what price would be needed to curb emissions. The model used two input points for carbon price – one for the cost which is incurred for emissions which are auctioned as a part of 15% below the total cap, and the other for emissions which exceed the cap (*Figure 9*). Although these two are separate emission auctions, the same carbon price was used due to evidence that, in fact, the two values have historically been nearly equal. For example, in November 2008, the value of a tonne of carbon on the European Climate Exchange (the open market) was €16.33 (European Climate Exchange, 2009) while the same day in the United Kingdom's (UK) auction for Phase II allowances, a tonne of carbon sold for €16.15 (Europa, 2009).

Figure 9 - ETS Diagram



3.2.4.1 Social Cost of Carbon (SCC)

The projected carbon costs listed in *Table 10* are considered to be the market cost of carbon (with the possible exception of the $200/tonne estimate by the National Roundtable on Environment and Economy) and are not inclusive of incremental costs (such as impacts attributed to the fact CO_2 emissions have a lengthy residency time in the atmosphere) which are incurred from emissions of CO_2 (Pearce, 2003). The SCC on the other hand attempts to include such costs and is a measure which is defined as the "value of the *climate change impacts* from one tonne of carbon emitted today as CO_2, aggregated over time and discounted back to the present day" (IPCC, 2007b, p.881). These estimates yield at least a comparable and often higher value than the market costs of carbon for the same mitigation scenarios (UN, 2008). Essentially, the SCC gives value to aspects which are not included in a traditional economic assessment (i.e. cost of increase in hazards and other non-market impacts) (UN, 2008). Like the cost of carbon on a market, estimates of SCC are also highly variable (see *Table 9*) and the methods used to estimate a cost are widely debated.

Table 9 - Social Cost of Carbon Estimates

Social Cost of Carbon	Details	Source
$26 (range $12-60)	using PAGE95	(Plambeck & Hope, 1996)
$9-$23	FUND model marginal costs (range depending on different discount rates)	(Tol, 1999)
$19 (range $4-$41)	using PAGE2002	(Hope, 2006)
$29-$129		(Nordhaus & William, 2005)
$200	Necessary to meet goals of 65% below current levels (2007) by 2050	(National Round Table on the Environment and the Economy, 2007)
$353		(Stern et al., 2006)
£70 (range £35-£140)	values should be increased at rate of £1/tonne of carbon/year	(Clarkson & Deyes, 2002)

* PAGE95, FUND and PAGE2002 refer to computer simulation models

Some of the key parameters which alter the SCC estimates are discount rates (an issue which due to the release of the *Stern Report* in 2006 has received much attention), equity weighting, time-horizon of the study and usage of mean versus median as the measure of central tendency (Watkiss, 2009).

An overarching conclusion with regards to the variance in SCC estimates is that those published in peer-reviewed literature are lower and with smaller uncertainty ranges than other sources, for example, grey literature by both governments and non-governmental organizations (NGO) (Tol, 2008). Notable as well is that more recent estimates of SCC are lower than those published historically (Hope, 2008); those published before the IPCC second report are higher than those released between the second and third reports which are again higher than those published since (see *Table 10*) (Tol, 2008)

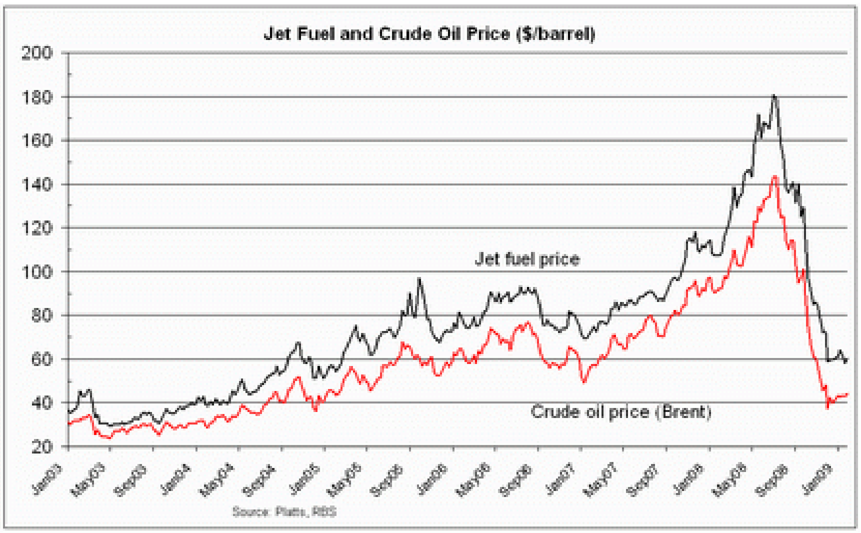
Table 10 – Meta-Analysis of the Spread of Social Cost of Carbon Estimates

Tol (2008) Social Cost of Carbon Comparison (results represent the mean estimate social cost of carbon from all publications in the time period noted)			
Distribution Technique	***Before 1996***	***1996-2001***	***2001-present***
Fisher-Tippett, sample standard deviation	190	120	88
Gauss, sample standard deviation	131	83	61
Gauss, sample coefficient of variation	125	100	68

3.2.5 Oil Price

As has been clearly depicted during the year of 2008, the price of oil is volatile and subject to shocks and market movements. The cost of a barrel of oil peaked at $133USD/barrel in July and then dropped to $40/barrel in December of 2008 (EIA, 2009) taking the global community on a 'roller coaster ride' of energy costs. Closely tied to oil is the price of jet fuel, which also fluctuated violently in 2008 (*Figure 10)*.

Figure 10 - Historical Jet Fuel and Crude Oil Price



Source: (IATA, 2009)

Airlines purchase jet fuel through hedging[8] (Johnson & Cottingham, 2008) When projecting to 2020, using the cost of oil as the indicator for both oil and jet fuel prices is acceptable, since what is key to the modeling is the percentage annual change. Since forecast data for jet fuel is much harder to come by, data for crude oil estimates are used instead. The one forecast which was found was from IATA's 2008 economic briefing and it only gave estimates for 2007, 2015 and 2020 (IATA, 2008). .

The range of oil price futures used in this research is taken from the Energy Information Administration (EIA) in the *International Energy Outlook* and is reported at a reference scenario which assumes relative stability as well as a high scenario which takes into consideration volatility which may occur. The reference scenario shows global oil prices at $77.9/barrel (USD) in 2020 while the high scenario has a barrel of oil costing $132.1 (USD) in the same year (EIA, 2008). Other organizations provide oil term price forecasts; IATA's price estimate is in line with the EIA's high scenario projection at $131/barrel (USD) (IATA, 2008).

3.2.6 Air Transport Fuel Efficiency

The distance between a given origin country and its destination remains constant and therefore it would be reasonable to assume that emissions from a flight are also constant. However, given aviation improvements in fuel efficiency, and often technology and management strategies, GHG emissions between the same two points are known to decline over time. In fact, airlines claim that since 1987 fuel consumption has been reduced by 37% per 100 passenger kilometres traveled and that aircraft burn 70% less fuel, and therefore emit approximately 70% less CO_2 emissions, than they did in the 1960s (AirBus, 2007b). The increasing efficiency in air transport was built into the model. There is a range of estimates given by different industry, non-governmental organizations and government agencies with regards to annual increases in aviation efficiency; a factor of 1.5% was used in the modeling (see *Table 11)*.

[8] Hedging is the process of "locking in the cost of future fuel purchases, which protects against sudden cost increases from rising fuel prices, but it also prevents savings from decreasing fuel prices" (Morrell & Swan, 2006, p.713)

Table 11 - Aviation Fuel Efficiency Factors

Average Fuel Efficiency Improvement Per Year	*Details*	*Source*
1.10%	Global Fuel Efficiency Improvements to 2012	(Jacobs Consulting Canada Inc., 2007)
1.50%	Average of 1-2%	(Kahn et al., 2007)
3.50%	Annual goal of fuel efficiency improvement (from 2000-2020)	(European Federation for Transport and Environment, 2008a)

3.2.7 Growth in Aviation

Different growth rates in air travel for NA (Canada and the United States) and Western Europe (primarily the UK but also Germany, Italy, France, Spain and the Netherlands) have been projected from different sources (*Table 12*). However, Boeing's (2008) estimates were used because that study was the only study that provided growth rates for both Europe to Latin America and North America to Latin America flights.

Table 12 - Annual Aviation Growth Rates

Aviation Annual Growth Rate		*Details*	*Source*
North America	*Europe*		
	6.0%	RPKs to Latin America (out to 2017)	(AirBus, 2007a)
	4.3%	RPKs between Caribbean and Western Europe (2007-2026)	(AirBus, 2007b)
	4.7%	Europe to Latin America (2007-2027)	(Boeing, 2008)
2.7%		Growth in Passengers for North America (2005-2025)	(Airports Council International, 2007)
5.30%		RPKs Canada-International Travel (excluding USA) (2006-	(Transport Canada, 2007)

		2020)	
3.5%		International Growth in Air Traffic from Canada	(Jacobs Consulting Canada Inc., 2007)
4.8%		North America to Latin America (2007-2027)	(Boeing, 2008)
2.4%		Domestic US (2007-2026)	(AirBus, 2007b)
4.2%		Passenger growth to Latin America (2007-2025)	(Federal Aviation Administration, 2008)

3.2.8 Flight Price

The flight cost input parameter is fundamental to the overall outcome of this research since it is the baseline for what a traveler would pay to fly to a certain destination without changes in cost due to external criteria such as climate policy and global oil prices. To determine the cost of a flight between each origin and destination country[9], two different time periods were chosen (one at high and one at low season) in order to try and give a range of cost levels for transportation. These time periods were February 7-14, 2009 and July 11-18, 2009. The analysis was done in November 2008 in order to have at least a 3-month gap between when one might book and the travel date (*Appendix B* lists the cost of a flight from each origin-destination for the February dates, those which were used in the model). Flight price estimates were taken from *airticketsdirect.com* to be consistent with the data source used by Gossling et al. (2008) to determine flight cost. For origin countries other than the United States, the website provided the cost in Canadian dollars. *Http.coinmill.com* was used to convert the values so that all flight cost baselines were reported in US dollars[10].

In most cases the flight in February (often considered peak or high season) was just as inexpensive or in some cases less expensive than the flight chosen for July (often considered low season). This is likely accounted for by the fact that July is a long time in the future and very few people

[9] *Table 13* lays out the airports used for each origin and destination modeled
[10] The values were exchanged at a rate of one Canadian dollar equal to one dollar and twenty-two cents American, the exchange rate on November 14, 2008.

will book a vacation at this point for July – the price of tickets will likely come down as the time gets closer.

Table 13 - Origin/Destination Airports

Destination Country	*Origin Country*							
	United States	*United Kingdom*	*Canada*	*Spain*	*France*	*Italy*	*Germany*	*Netherlands*
Anguilla	JFK[11]-AXA[12]							
Antigua and Barbuda	JFK-ANU[13]	LHR[14]-ANU						
The Bahamas	JFK-NAS[15]							
Barbados	JFK-BGI[16]	LHR-BGI	YYZ[17]-BGI					
Belize	JFK-BZE[18]							
Bermuda	JFK-BDA[19]							
British Virgin Islands	JFK-EIS[20]	LHR-EIS						
Cayman Islands	JFK-GCM[21]							

11 John F. Kennedy Airport, New York, USA
12 Anguilla Wallblake Airport, Anguilla
13 V. C. Bird International Airport, Antigua
14 Heathrow Airport, London, UK
15 Nassau International Airport, Nassau, Bahamas
16 Grantley Adams International Airport, Bridgetown, Barbados
17 Pearson International Airport, Toronto, Canada
18 Philip S.W. Goldson International Airport, Belize City, Belize
19 Bermuda International Airport, Bermuda
20 Beef Island International Airport, British Virgin Islands
21 Owen Roberts International Airport, Grand Cayman Island

Cuba		LHR-HAV[22]	YYZ-HAV	BCN[23]-HAV		FCO[24]-HAV		
Dominica	JFK-DOM[25]	LHR-DOM						
Dominican Republic	JFK-SDQ[26]	LHR-SDQ	YYZ-SDQ	BCN-SDQ	CDG[27]-SDQ		FRA[28]-SDQ	
Grenada	JFK-GND[29]	LHR-GND	YYZ-GND					
Guyana	JFK-GEO[30]		YYZ-GEO					
Haiti	JFK-PAP[31]							
Jamaica	JFK-KIN[32]							
Puerto Rico	JFK-SJU[33]							
St. Lucia	JFK-UVF[34]	LHR-UVF						
St. Vincent and the Grenadines	JFK-SVD[35]	LHR-SVD						

[22] Jose Marti International Airport, Havana, Cuba
[23] Barcelona International Airport, Barcelona, Spain
[24] Rome Leonardo da Vinci (Fiumicino) Airport, Rome, Italy
[25]Melville Hall Airport, Dominica
[26] Las Americas International Airport, Santo Domingo, Dominican Republic
[27] Charles de Gauelle International Airport, Paris, France
[28] Frankfurt International Airport, Frankfurt, Germany
[29] Point Saline International Airport, Greneda
[30] Cheddi Jagan International Airport, Georgetown, Guyana
[31] Mais Gate Airport, Port Au Prince, Haiti
[32] Norman Manley Airport, Kingston, Jamaica
[33] Luis Munoz Marin International Airport, San Juan, Puerto Rico
[34] Hewanorra Airport, St. Lucia
[35] E.T. Joshua Airport, St. Vincent, St. Vincent and the Grenadines

Suriname								AMS[36]-PBM[37]
Trinidad and Tobago	JFK-POS[38]	LHR-POS	YYZ-POS					
Turks and Caicos	JFK-PLS[39]							

[36] Amsterdam Schiphol International Airport, Amsterdam, the Netherlands
[37] Zanderij International Airport, Paramaribo, Suriname
[38] Piarco Airport, Port of Spain, Trinidad and Tobago
[39] Providenciales International Airport, Providenciales, Turks and Caicos

3.2.9 Air Travel Price Elasticity

Demand for a product is a function of two things, its price and the nature of its demand curve; the demand curve is dependent on its position and its slope which is the value of the product's price elasticity (Crouch, 1992). Price elasticity of any given product is "the percentage change in the quantity demanded of a good (or service) resulting from a given percentage change in the good's own-price, holding all other independent variables (income, prices of related goods etc.) fixed (Gillen, Morrison, & Stewart, 2004). A product is considered to be at unity elasticity if it has a value below -1, values above -1 are considered to be relatively inelastic and a value of 0 is perfectly inelastic. Values below -1 are considered to be relatively elastic. In basic terms this means that if a product had an elasticity value of -0.75 and the price increased 1%, the demand for the product would decline by 0.75% (Clayton, 2003).

Price elasticity, has been used for decades as an indicator for international travel demand and along with income elasticity, it is the most frequently cited factor in economic demand theory in the tourism field (Crouch, 1992) Over the years, studies have been done looking at many different aspects of tourism (*Table 14).*

Table 14 - Price Elasticity Tourism Studies

Price Elasticity Studies		
Type of Study		***Source***
Specific Destinations		
	Thailand	(Vogt & Wittayakorn, 1998)
	Denmark	(Jensen, 1998)
	Mediterranean	(Papatheodorou, 1999)
Visitor Origins		
	US and European	(Syriopoulos & Sinclair, 1993)
Trip Components		
	Air Travel	(Brons et al., 2002; Njegovan, 2006)
	Accommodation	
Travel Type		(Taplin, 1997)
	Wander-lust versus Sun-lust	(Crouch, 1995)
Meta analyses		(Crouch, 1995; Lim, 1999)

Although the studies done are numerous, there is no agreed upon price elasticity for travel. However, determining estimates for the price elasticity of international travel has led the way to a better understanding of how the industry might react to different global economic events.

Using price elasticity of long haul air travel (*Table 15*) and the literature, the low, average and high values used in the research model were obtained. The average value used for the EU to Caribbean was -1.295, while NA's average value to the Caribbean was -1.195. A high and a low elasticity value were also modeled – high for North America of -1.4 and -1.7 for Europe – with a low of -1.04 for both regions. The range of elasticity values provided a sensitivity analysis for the model.

Table 15 - Long Haul Aviation Elasticities

Elasticity Value	***Details***	***Source***
-1.4	Intra North America, Long Haul Flights	(InterVISTAS Consulting Inc., 2007)
-1.7	Trans-Atlantic Long Haul Flight	(InterVISTAS Consulting Inc., 2007)
-1.146	Mean aviation	(Brons et al., 2002)
-1.04	Long-Haul International Leisure Air Travel	(Gillen et al., 2004)

3.2.10 Inflation and Exchange Rate

Given the uncertainty of the global economic marketplace, this research assumed that inflation would increase at the same rate as economic growth over the period of the study (to 2020), therefore each cancelling out the effects the other would have in the model. Other studies which model the impact of climate policy on arrivals (Gossling et al., 2008; Tol, 2006) did not include factors to adjust for inflation and economic growth and this model has been constructed in a similar manner.

Monetary values in the model are in 2008 US dollars and the exchange rate used in calculations was taken from the Bank of Canada for November 14, 2008 – the date which flight ticket cost data was collected.

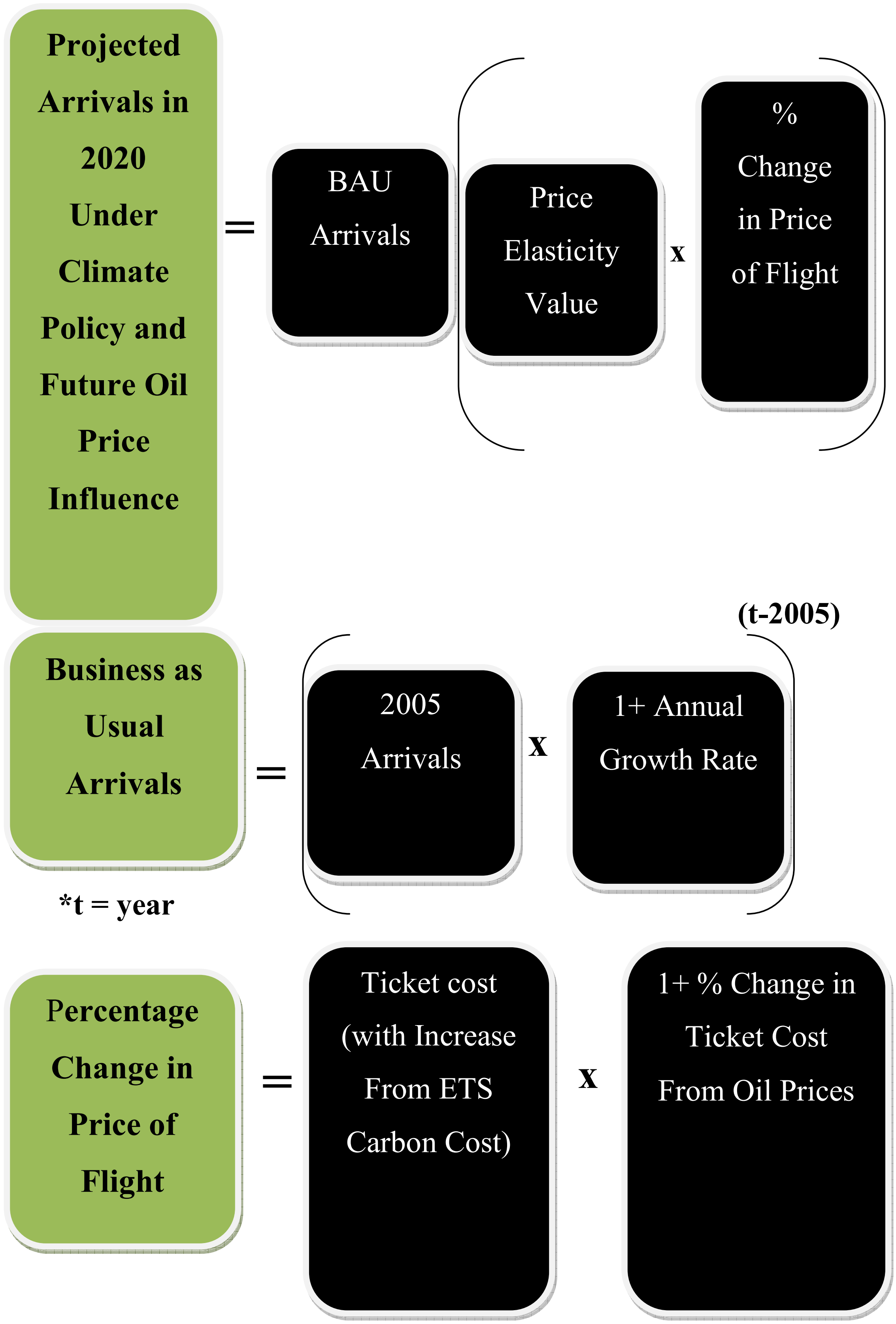
3.3 The Model

The model constructed for this study is conceptually similar and builds on the work of Gossling et al's (2008) study of the impact of mitigation policy for visitor numbers to a sample of tourism dependent island nations across the globe. This research adds new parameters and makes adjustments for previous assumptions that have become outdated. The Gossling et al (2008) model did not include a fuel price parameter which, given the volatile performance of oil prices in the past months as well as projected longer term affects (Becken, 2008; Yeoman et al., 2007) was thought to be important. Determining how future oil prices might impact the cost of a flight to a Caribbean country and therefore how it might impact total arrival numbers and consequently the tourism industry of the destination country itself was a process which provided crucial information to retrieve a more complete look at the potential future for the Caribbean tourism sector. Also, at the time the Gossling et al (2008) model was prepared, the EU ETS had in place targets of a 21% reduction by 2020 for aviation, but that target has been drastically reduced to only a 5% reduction by the same year (EurActiv, 2008). The model used in this study also included a NA ETS component, utilized an industry source calculator (ICAO's) for emission estimates and inputted a fuller range of price elasticity values from the literature than was used in the Gossling et al. (2008) model. Furthermore, the model is presented in such a way that it can be used in subsequent research as well as for different areas of the world.

3.3.1 Modeling the Data

There were four main stages to the model – the arrival numbers and other basic computations which are described in the previous sections, calculations and increase in cost due to the ETS, calculations and increase in cost due to oil price and calculations and the input of price elasticity values to determine the overall change in arrivals due to price increases from emissions and oil price (see *Figure 11* for an overview; *Appendix C* for more detail).

Figure 11 - Model to Determine Change in Arrivals



3.3.1.1 Arrival and Emissions Projection

There are a number of steps that had to be completed before the model could be run. First, it was crucial to determine which of the UNWTO arrivals data was applicable to this study. The initial step was to look at each of the 23 Caribbean countries within the scope of the study and determine which market countries contributed significant tourist arrivals. For each Caribbean destination, the market countries which (either on their own or combined with others) made up at least 60% of arrivals and were located within either NA or EU were considered significant. For example, for Antigua and Barbuda, the United States (US) and United Kingdom (UK) together made up 65% of arrivals and were therefore the significant origin markets modeled. The threshold of 60% was chosen as it appeared that above this (i.e. 70% or 80%) there would be too many origin countries involved for each destination country and therefore the modeling would become time consuming, without any marked improvement in the results. In addition, in some cases going beyond the 60% threshold introduced problems of data availability. An example of this is Cuba which, at a 60% threshold had six different origin countries, one of which is actually not specific and is termed "all other Caribbean countries".

Once the significant origin countries were determined for each of the 23 Caribbean destinations then the percentage of arrivals for each significant origin country was calculated for the year 2005. Growth rates were calculated using arrival numbers from 2000-2005 and averaging the growth rate over the five year period.

The cost of a flight from the market to destination country for the February 7-14, 2009 time frame was taken from *airticketsdirect.com* and the CO_2 emissions released between each origin and destination was obtained using the ICAO online calculator.

Determining what, in a BAU scenario, arrival numbers to the different destinations would be in the future was calculated by using the 2005 arrival number for the origin countries and growing this at an annual rate – in this case the growth rate calculated from 2000-2005. For example, in the destination country of Antigua and Barbuda, the 2005 arrival number for the United Kingdom (which represents 37.93% of arrivals) is 90,568. This number was then multiplied by the growth rate for total arrivals to Antigua and Barbuda for the 2000-2005 time period which resulted in arrival numbers for 2006 to be projected at 93, 439. Column 'A' in *Table 17* depicts the resulting arrival projections for UK visitor arrivals to Antigua & Barbuda from 2006-2020, and *Example Box 1* gives the detailed calculation for 2006 arrivals.

Example Box 1

2005 arrivals x (1+ Growth Rate) = 2006 BAU Arrivals

(90568) x (1+0.0317) = 93439

Determining the annual emissions was done by taking the emission estimate from the ICAO online calculator between a given origin country and the Caribbean destination. For round trip passengers leaving from the UK (leaving from London, Heathrow) to the airport on Antigua, emissions were calculated to be 1.311 tonnes of CO_2. As noted earlier, this does not take into consideration impacts from non- CO_2 sources so the climate impact is likely to be two to five times higher than the amount given by the ICAO calculator (Johnson & Cottingham, 2008). Given that advancements in aircraft efficiency are ongoing, emissions for the same distance would decline annually. The air transport fuel efficiency factor that was used in this model was 1.5%/yr which is a commonly accepted efficiency gain factor (Kahn et al., 2007). Some sources have claimed efficiency improvements are likely to be 3.5%/year but there is little proof of that in the literature (European Federation for Transport and Environment, 2008a). In order to determine what the emissions would be in 2020 from any given origin to destination, each year the 1.5% efficiency factor was applied to the previous year's emissions. For example, to determine the 2010 emissions from the UK to Antigua & Barbuda the 1.311 tonnes of CO_2 was multiplied by 1.5% efficiency gain, giving a result of 1.292 tonnes of CO_2. This was then done in each consecutive year. To be accurate, a decrease in efficiency of 1.5% was applied to emissions annually for 2006-2008 as they were prior to the emission estimate given by the ICAO calculator. Column 'B' in *Table 17* (p 71). depicts the results for each of the years for UK to Antigua and Barbuda (2006-2020) and *Example Box 2* gives the calculation.

Example Box 2

2009 Tonnes of Carbon - (2009 Tonnes of Carbon x Air Transport Fuel Efficiency Factor) = 2010 Tonnes of Carbon

1.312 – (1.312 x 0.015) = 1.292

3.3.1.2 ETS Components

Incorporating the ETS components into the model was critical to be able to determine how climate policy might impact flight costs and overall arrivals to Caribbean countries. The initial step was to calculate a baseline for emissions from NA (used in Canada and USA calculations) and EU (used in UK, France, Spain, Germany, Italy and the Netherlands calculations). The baseline of 100 was used as the 2005 emission number for both NA and the EU. Two calculations are made to project aviation emissions from each region. First, the baseline was multiplied by the projected growth of aviation in the region (for NA 4.8% and for EU, 4.7%) – this was done each year on the previous year's emissions in order to determine total projected emissions from the two regions. Second, to each of these calculations, the annual fuel efficiency increase of 1.5%/year was also included. This calculation gave the projected total emissions from aviation for NA and for the EU. *Table 16* details the results of these calculations while *Example Box 3* shows a detailed calculation.

Table 16 - NA and EU Aviation Emission Projections (2005-2020)

NA						
Year	Total Projected Aviation Emissions NA (as % of 2005 baseline) **(I)**	Cap **(II)**	15% of Cap which is the Allowable Auction (tonnes of CO_2) **(III)**	Gap Existing Between Cap and Projected Emissions (tonnes of CO2) **(IV)**	Percentage of Emissions above Cap **(V)**	Percentage of Emissions which are designated Allowable Auction **(VI)**
2005	100.000					
2006	103.228					
2007	106.560					
2008	110.000					
2009	113.551					
2010	117.216					
2011	121.000					
2012	124.906	97	14.550	27.906	22.3%	11.6%
2013	128.938	95	14.250	33.938	26.3%	11.1%
2014	133.100	95	14.250	38.100	28.6%	10.7%
2015	137.396	95	14.250	42.396	30.9%	10.4%
2016	141.831	95	14.250	46.831	33.0%	10.0%
2017	146.410	95	14.250	51.410	35.1%	9.7%

2018	151.136	95	14.250	56.136	37.1%	9.4%
2019	156.015	95	14.250	61.015	39.1%	9.1%
2020	161.051	95	14.250	66.051	41.0%	8.8%

EU						
Year	Total Projected Aviation Emissions EU (as % of 2005 baseline) **(I)**	Cap **(II)**	15% of Cap which is the Allowable Auction (tonnes of CO_2) **(III)**	Gap Existing Between Cap and Projected Emissions (tonnes of CO_2) **(IV)**	Percentage of Emissions above Cap **(V)**	Percentage of Emissions which are designated Allowable Auction **(VI)**
2005	100.000					
2006	103.130					
2007	106.357					
2008	109.685					
2009	113.118					
2010	116.658					
2011	120.309					
2012	124.074	97	14.550	27.074	21.8%	11.7%
2013	127.957	95	14.250	32.957	25.8%	11.1%
2014	131.961	95	14.250	36.961	28.0%	10.8%
2015	136.091	95	14.250	41.091	30.2%	10.5%
2016	140.350	95	14.250	45.350	32.3%	10.2%
2017	144.742	95	14.250	49.742	34.4%	9.8%
2018	149.272	95	14.250	54.272	36.4%	9.5%
2019	153.943	95	14.250	58.943	38.3%	9.3%
2020	158.761	95	14.250	63.761	40.2%	9.0%

Example Box 3

(2005 Aviation Emissions for the EU x (1+ EU Aviation Growth Rate)) x Air Transport Fuel Efficiency Factor = 2006 Aviation Emissions for the EU

(100 x 1.047) x 0.985 = 103.130

The next step was to take emissions for each year and determine the percentage that would fall within the auction allowance (the 15% below the cap set) for an ETS and what percentage of them would be above the cap, which was 97% (of average aviation emissions between 2004-2006) for 2012 and 95% for 2013-2020. It was assumed that the ETS would be implemented in 2012 (as is planned in the EU) and calculations of carbon costs on flights began then. In order to determine what the cap would be, the 2005 baseline was multiplied by the percentage cap for the given period. From here it was necessary to determine the amount of the allowable emissions that fell within the percentage of allowances that would be auctioned and not assigned free of charge. This was done by multiplying the total allowance (95% or 97% of the 2005 baseline) by the percentage allowances to be auctioned (15%). Then, to determine what emissions that would be above the stated cap the emissions allowed under the cap was subtracted from total projected emissions (as calculated). Results from these calculations are shown in *Table 16,* EU columns `V` and `VI` and a detailed calculation provided in *Example Box 4*.

Example Box 4

Allowable Auction Emissions

Set 2012 allowable emission amount (15% of cap)/Total 2012 emissions for EU = Percentage of EU emissions for 2012 that fall under allowable auction

(97*.15) /124.0738862 = 0.117

Emissions Above Cap

(Total 2012 emissions for EU - Emission Cap for 2012)/Total 2012 Emissions for EU = Percentage of EU emissions that are above the cap

(124.073-97)/124.0738862 = 0.218

Once the general emission information was collected it was used within each different destination's calculations to determine their specific change in arrivals due to the ETS factors. Beginning in the year of ETS implementation, the projected emissions from the origin country (in this example, the UK) to the destination country (in this example, Antigua and Barbuda) were multiplied by the percentage above the cap. This resulted in tonnage of CO_2 within the chosen flight which would be auctioned as allowances under the ETS cap. This was done for each year from 2012-2020. To determine the emissions over the cap a similar process was undertaken but the total emissions from the UK-Antigua & Barbuda trip are this time multiplied by the percentage of EU aviation for the same year which is above the set cap. Column's 'C' and 'D', respectively, of *Table 17* illustrate these results and *Example Box 5* gives a detailed calculation.

Example Box 5

Auction Allowance for UK to Antigua and Barbuda

Percentage of emissions under auctioned allowance for EU in 2012 (*Table 16* column VI) x Emissions in 2012 for UK to Antigua and Barbuda = 2012 Emissions (in tonnes of CO_2) for the UK to Antigua and Barbuda trip that are under the allowable auction

0.117269 x 1.254 = 0.147 tonnes

Above Cap for UK to Antigua and Barbuda

Percentage of emissions above cap for EU in 2012 (*Table 16* column V) x Emissions in 2012 for UK to Antigua and Barbuda = 2012 Emissions (in tonnes of CO_2) for the UK to Antigua and Barbuda trip that are above the cap

0.2182078 x 1.254 = 0.274 tonnes

The next step was to take the CO_2 emissions which fell within the 15% auction and multiply them by the cost per tonne (in USD dollars) set for that level. This was added to the CO_2 emissions projected above the set cap which had been multiplied by the cost per tonne (in US dollars) laid out. This would then give the price increase per flight ticket based on climate policy (column 'E' in *Table 17* shows the results while *Example Box 6* gives a detailed calculation).

Example Box 6

(2012 UK to Antigua and Barbuda emissions for allowable auction x Cost per tonne of CO_2) + (2012 UK to Antigua and Barbuda emissions above cap x Cost per tonne of CO_2) = 2012 Additional cost per ticket from ETS

(0.147 x \$16) + (0.274 x \$16) = \$6.729

To determine the percentage increase in cost of a ticket attributed to ETS versus the baseline cost of 2008, the price of a flight for February 2009 was used. The calculation was a matter of dividing the added cost from the ETS on a flight (illustrated in column 'E' of *Table 17)* by the 2008 cost of a flight from the origin to the destination. This calculation was done for only the years of ETS implementation and the results are illustrated in *Table 17*, column 'F'; the calculation is shown in *Example Box 7.*

> **Example Box 7**
>
> Additional cost per ticket from ETS in 2012/Cost of a flight in 2008 = 2012 Percentage increase in cost attributed to ETS
>
> $6.72/1307.98 = 0.00514 *or* 0.514%

The final calculation specific to the ETS components was to determine the total cost of a ticket with the ETS price increase included. This was done by adding the increase in cost per trip to the 2008 flight cost which was also previously determined and is illustrated in column 'G' of *Table 17* and *Example Box 8*.

> **Example Box 8**
>
> Cost of a flight in 2008 + 2012 Additional cost per ticket from ETS in 2012 = 2012 Total cost of a ticket with the ETS
>
> $1307.98+$6.72 = $1314.709

3.3.1.3 Oil Price Components

To determine the increase in ticket cost that would be associated with oil prices; the oil price forecast given out to 2020, from the US EIA, was used. The year to year percentage increase in price was used as the baseline price increase for a flight ticket for the corresponding year. But, since fuel (oil) only accounts for an estimated one third of the cost of a flight, the percentage increase of the cost of oil was multiplied by 0.3 to determine the percentage increase that would be applied to the ticket cost of a flight between a given origin and destination. Column 'H' in *Table 17* illustrates this and *Example Box 9* shows the calculations.

> **Example Box 9**
>
> 2012 percentage increase in cost of oil (from the EIA forecast) x 0.3 = 2012 Percentage increase in cost to be applied to the total ticket cost of a flight
>
> 0.478 x 0.3 = 0.014 or 1.4%

3.3.1.4 Price Elasticity and Output Arrival Numbers

The final step in determining how arrivals to the Caribbean could change given climate policy and fluctuating oil prices was done in three parts. First, it was necessary to determine what a ticket would cost given increases associated with both an ETS and future oil prices. This was done by multiplying the ticket cost with the ETS component included (which had already been calculated) by the percentage increase in ticket cost due to rising oil prices. It is important to note, when calculating the ticket price with the only the ETS cost included, the additional cost was always added to the base year because, all things being equal, if the ETS did not exist then the flight cost would be the same. That is, the ETS does not build year upon year. The calculation of oil prices, on the other hand is a cumulative increase and, therefore, when it is included it builds on the previous year. For example, when oil price increases 10% in year one, a 5% increase in year 2 applies to the full 110% in year one whereas a charge for 'x' tonnes of CO_2 in year one is the same flat fee in year two. The results of this step are illustrated in column 'I' of *Table 16* and calculations detailed in *Example Box 10*.

Example Box 10

2012 Ticket cost with ETS included x (1+ Percentage change from the cost of oil) = 2012 Total cost of a flight with ETS and oil included

$1314.709 x 1.014341 = $1333.563

To determine the total price percentage change with the climate policy and future oil price factored in, the calculation divided the flight price with both costs included by the baseline flight cost (that which was determined in 2008). *Table 16*, EU column 'I' shows an example of this step and *Example Box 11* shows the calculation

Example Box 11

(2012 Total cost of a flight with ETS and oil included – Ticket cost in 2008)/Ticket cost in 2008 = Percentage Increase in ticket cost from ETS and oil

($1333.563-$1307.98)/$1307.98 = 0.019559167 *or* 1.95%

The final major calculation is to determine what change in arrivals could occur given the increase in flight cost that has been associated with climate policy (in the form of an ETS) and oil price fluctuation. In order to calculate the change in arrivals, the economic measure of price elasticity was used. The usage of price elasticity in this sort of calculation has been used by many researchers in different fields and even as recently as in some pre-Copenhagen aviation fee/levy discussions (Muller, 2008). This calculation gave a projection of actual arrival number changes which then was converted to percentage change above or below the arrivals in a BAU scenario in any given year. This was done by subtracting the BAU arrivals from the arrival numbers calculated with ETS and oil price costs included in the flight and then dividing by the BAU scenario. Column 'K' of *Table 17* shows the results of this calculation and column 'L' gives the percentage change associated with 'K'. *Example Box 12* shows the calculations.

Example Box 12

Projected Arrivals for 2012

((Price elasticity x percentage increase in cost of a ticket with ETS and oil prices factored in) + 1) x projected BAU arrivals for 2012 = projected arrivals for 2012 with ETS and oil prices factored in.

((-1.04 x 0.019559167) + 1) x 112681 = 110388

Percentage Change in Arrivals for 2012 vs. 2012 BAU

(Projected arrivals for 2012 with ETS and oil prices factored in – 2012 BAU arrivals) / 2012 BAU arrivals

(110388 – 112681) / 112681 = -0.0203495 *or* -2.03%

Table 17 - Example of Model Calculation

UK-Antigua & Barbuda												
Basic Inputs			**ETS-Carbon Cost Components**					**Oil cost components**				
Year	Projected Arrivals Under BAU Growth **'A'**	Projected Emissions Per Roundtrip (tonnes) **'B'**	Emissions Within 15% Auction **'C'**	Emissions Above Cap **'D'**	Additional Cost Per Ticket (From Carbon Costs) **'E'**	% Increase in Ticket Cost Versus 2008 Cost **'F'**	Ticket Cost with Carbon Cost Included **'G'**	% Increase in Ticket Cost From Oil Price **'H'**	Total Ticket Cost With Carbon Cost and Oil Price **'I'**	Total Ticket Cost Increase (%) vs. 2008 **'J'**	Visitor Arrivals With New Costs of Carbon and Oil **'K'**	Percentage Change in Arrivals Versus BAU **'L'**
2006	93439	1.372						0.051				
2007	96401	1.351						0.029				
2008	99457	1.331					1307.980	0.117	1461.476	0.117	87318	-12.2
2009	102610	1.312					1307.980	-0.024	1276.350	-0.024	105190	2.5
2010	105862	1.292					1307.980	-0.022	1279.006	-0.022	108301	2.3
2011	109218	1.273					1307.980	0.014	1326.622	0.014	107599	-1.48
2012	112681	1.254	0.147	0.274	6.729	0.514%	1314.709	0.014	1333.563	0.020	110388	-2.03
2013	116252	1.235	0.138	0.318	7.288	0.557%	1315.268	0.014	1333.858	0.020	113860	-2.06
2014	119938	1.216	0.131	0.341	7.552	0.577%	1315.532	0.013	1333.289	0.019	117524	-2.01
2015	123740	1.198	0.125	0.362	7.794	0.596%	1315.774	0.013	1333.345	0.019	121244	-2.02
2016	127662	1.180	0.120	0.381	8.017	0.613%	1315.997	0.012	1332.345	0.019	125189	-1.94
2017	131709	1.162	0.114	0.399	8.222	0.629%	1316.202	0.015	1336.523	0.022	128720	-2.27
2018	135884	1.145	0.109	0.416	8.409	0.643%	1316.389	0.010	1329.913	0.017	133515	-1.74
2019	140192	1.128	0.104	0.432	8.579	0.656%	1316.559	0.013	1333.336	0.019	137365	-2.02
2020	144636	1.111	0.100	0.446	8.733	0.668%	1316.713	0.012	1332.995	0.019	141759	-1.99

3.3.2 Scenario Characteristics

It was important to run a wide spectrum of scenarios which modified some of the variables in the model in order to be able to determine which aspects might have the most impact on changing arrival numbers to Caribbean destinations. Although it is technically possible to modify almost all of the variables inputted into the model, in reality the time that this would require is unfeasible for a project of this size. It was decided, then, that three main variables of specific interest to this analysis would be modified:

1. *The cost of oil*: modifying the cost of oil is important given the uncertainty that has been seen in oil prices over the past year and is likely to continue. It is impractical to believe that one forecast for 2012-2020 would be accurate and so, based on forecasts from the United States EIA, a reference (low) and high oil price forecast scenario were used within the scenarios. Scenarios 1-9 used the high oil price forecast while scenarios 10-18 used the reference oil price forecast. Scenario 19 was modeled with a combination of the two which is discussed in detail in section *3.3.2.1*.

2. *The cost of carbon within a proposed ETS*: modifying the cost of carbon is a necessary factor within the scenarios as it is currently a volatile measure and it would be inaccurate to simply pick a single price which may represent the high, low or median cost and assume that it would be representative of what carbon would cost from 2012 right through to 2020. Therefore, three different carbon prices (low, medium and high) were used through the different scenarios. The low estimate was used in scenarios 1 to 3 and 10 to 12; the medium in scenarios 4 to 6 and 13 to 15 and the high estimate in scenarios 7 to 9 and 16 to 18. The 'serious' climate policy scenario used a social cost of carbon of $200.

3. *The price elasticity of the air travel*: price elasticity is a very uncertain measure and there are many proposed elasticities which cover a wide range of values (see section 3.2.9). Because of this, it was necessary to use three different measures of price elasticity (low, average and high) to understand how much of an impact this factor has on the outcome of the model. The low estimate was used in scenarios 1,4,6,10,13 and 16; the average in scenarios 2,5,8,11,14 and 17 and 'serious' climate policy and the high estimate was used in scenarios 3,6,9,12,15 and 18.

These three variables were altered to give 18 scenarios. The 19th scenario developed was done to give an estimation of what visitor arrivals to the Caribbean could be under a 'serious' climate policy situation. Each of the 18 main scenarios had a constant aviation efficiency factor of 1.5%, constant aviation growth, 4.8%/annually for NA origin countries and 4.7%/annually for EU origin countries, and that the ETS would be applied identically in both NA and the EU. Also, with regards to the inputs from the UNWTO data for destinations (e.g. annual growth rate), no modification was done on a scenario by scenario basis; instead this information remained the same for all 18. The 19th scenario, although not likely to be implemented within the timeframe of this study, provide a look ahead to what is quite probable in terms of climate policy in the coming decades. Each of the 19 scenarios was run for 21 of the 23 destination countries identified earlier. Montserrat and St. Kitts & Nevis were excluded from the modeling process due to data available for this research.

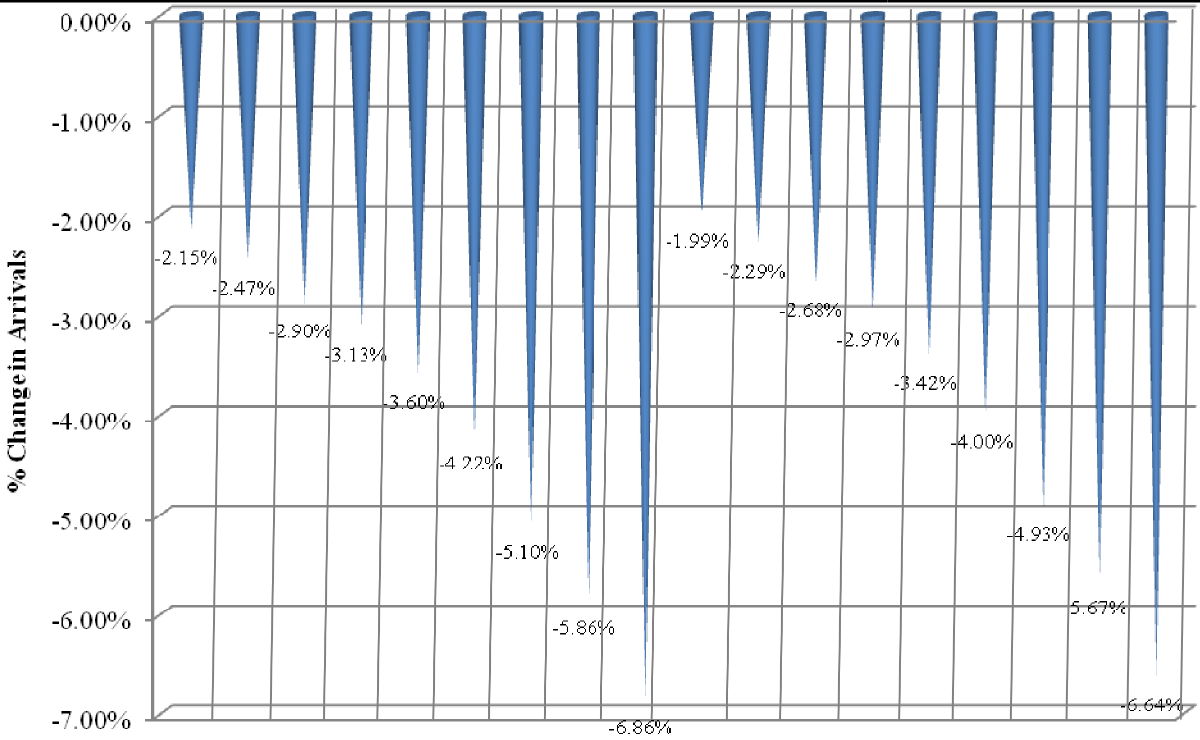
The combination of variables used in scenarios 1 to 18 are outlined in *Table 18* and the 'serious' climate policy scenario is described below. Beneath *Table 18* is an example of the one country's model output in order to give a visual example of which scenarios led to what change in arrivals. The figure is for Bahamas which will be discussed in more detail in section *4.3*.

3.3.2.1 'Serious' Climate Policy Scenario

The serious climate policy scenario kept the same aviation growth rates as the previous 18 scenarios, 4.8% for NA origins and 4.7% for EU origins; as well it used the average elasticity values for these two regions. Again, the serious climate policy scenario assumed an ETS in both origin regions – NA and the EU and that the aviation efficiency factor was 1.5%/year. The oil prices which were inputted into this scenario were a combination of the reference and high oil scenarios. It was assumed that forecasts to 2012 were likely reliable and so the values in the reference scenario to that point were used (a $76.5 USD value for 2012) but from there the prices were increased in a linear fashion to get to the high scenario's forecast value for 2020 ($132.10 USD). Emissions calculated in scenarios 1-18 were multiplied by a factor of 2.7 to account for all the non-CO_2 impacts which air travel has on the changing climate; this is the estimate put forth by the IPPC's report on *Aviation and the Global Atmosphere* (1999). The price of carbon was set at $200/tonne, a number which is considered to be more of a social cost of carbon and, although this number is on the high end of some estimates of SCC it is also below others so it was taken as a middle estimate.

Table 18 - Model Variables Used in Each Scenario

	Scenario																	
Model Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*
Oil Price Forecast[40]	H	H	H	H	H	H	H	H	H	L	L	L	L	L	L	L	L	L
Price Elasticity[41]	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H
Carbon Cost[42]	L	L	L	M	M	M	H	H	H	L	L	L	M	M	M	H	H	H



Bahamas Arrival Changes in 2020 verus BAU

[40] The high (H) oil price forecast has a price of $56.50 in 2005 and $132.10 in 2020 (in US dollars) while the reference (L) forecast has a price of $56.50 in 2005 and $77.90 in 2020 (in US dollars) (EIA, 2008)

[41] The low (L) price elasticity estimate is -1.04 for both EU and NA (Gillen et al., 2004); the average (M) estimate for EU is -1.295 and for NA is -1.195 (Brons et al., 2002; Gillen et al., 2004; InterVISTAS Consulting Inc., 2007)and the high (H) price elasticity estimate is -1.7 for EU and -1.4 for NA (InterVISTAS Consulting Inc., 2007)

[42] The low (L) carbon cost estimate is $16 (US dollars) (European Climate Exchange, 2009); the middle (M) estimate is $31 (US dollars) (JP Morgan, 2007) and the high (H) cost of carbon estimate is $61 (US dollars) (Fortis, 2008).

3.4 Chapter Summary

This chapter expressed, in detail, the process and criteria used for each of the nineteen scenarios modeled within the research. It also expressed explanations and discussions about limitations to data and available resources as well as why specific values or sources were used to determine inputs into the model. A step by step analysis of the calculations undertaken within the thesis model was offered in order that such research could be duplicated or performed on different origin and destination pairings. Results from the model and discussion will follow in the ensuing chapters.

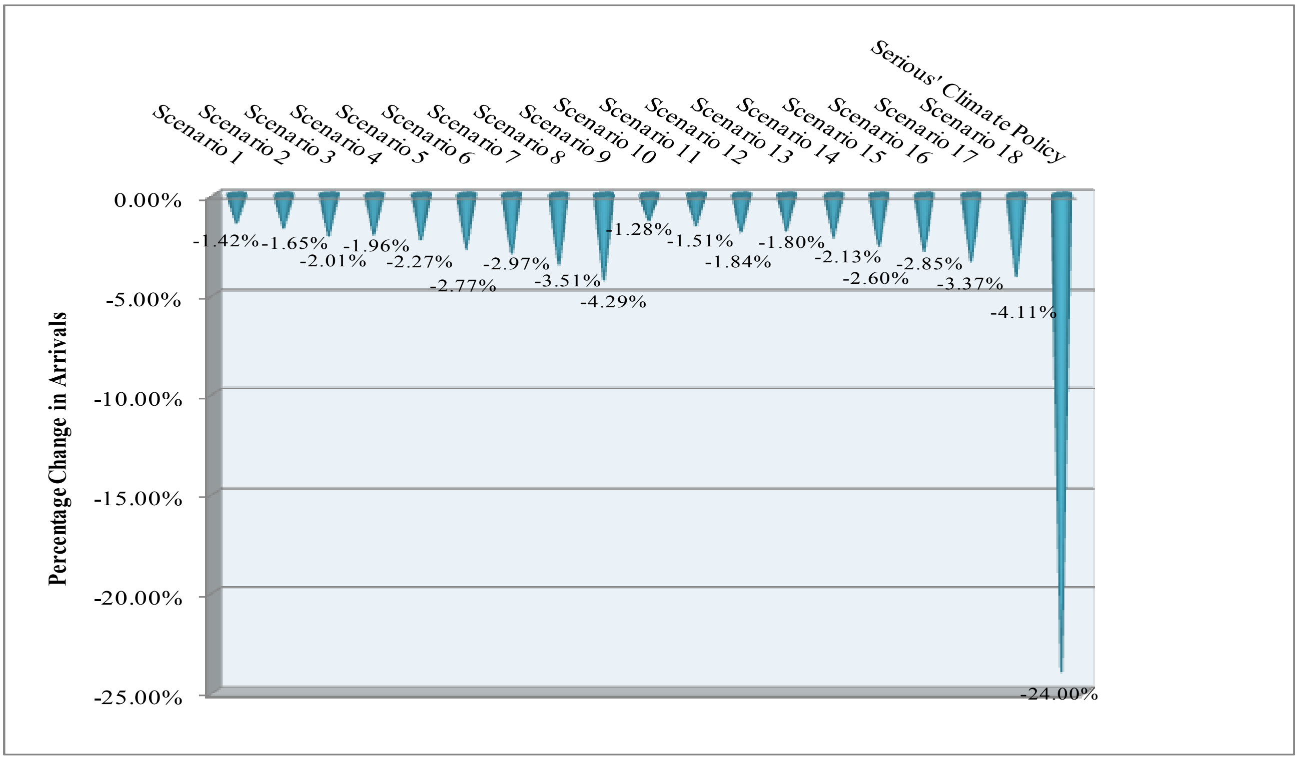
4.0 Results

The results of the modeling indicate which conditions would lead to the region experiencing the greatest (and the least) change in arrival numbers from air travel through to the year 2020 versus a BAU scenario. The change in arrivals numbers occurs as a consequence of the forecasted increase in price for a flight to the Caribbean destination countries. This additional cost is a condition of the fluctuating cost associated with aviation fuel (represented by oil price) and the cost of carbon necessary to fulfill requirements under an ETS (implemented in both the EU and NA). The consumer reaction to this price change, and subsequent change in arrivals, is determined by the price elasticity value inputted. Results from each of the 18 scenarios, at both individual destination nations as well as at the regional level, are consistent in their output of the highest and lowest impact scenarios; scenario nine and ten, respectively (See *Appendix A* for detailed destination level output charts). The 'serious' climate policy scenario (#19), as would be expected, projected negative impacts much greater than all other scenarios.

4.1 Results for the Caribbean Region

Because the Caribbean is made up of many different SIDS and small coastal states, and therefore is often considered together as a region, it is important to be able to report results not just for specific destinations but also as a regional average. On a whole, this region is expected to have fewer visitors than expected under the 2020 BAU scenario when climate policy and future oil prices are taken into consideration. Every scenario indicated a decline; in general, scenarios one to nine have lower percentage declines than their counterparts, scenarios ten to eighteen (see *Table 18* for more detail on the different scenario make-ups). *Figure 12*, depicts the overall regional change in arrivals for these eighteen scenarios and the 'serious' climate policy scenario versus what would occur in 2020 under BAU.

Figure 12 - 2020 Regional Percentage Change in Arrivals Including Serious Climate Policy (versus BAU)



From this figure it is clear that the arrival changes do not follow a completely linear path, as they might be expected to, but instead there appear to be some anomalies – specifically in scenarios four and thirteen. This differentiation will be discussed in section 4.4.

The nineteenth scenario, the 'serious' climate policy, indicates carbon costs and emission caps which are more indicative of what is thought to be required to make meaningful progress on the deep cuts in GHG emissions considered needed to avoid 'dangerous' climate change. The regional results from this scenario model indicate that, as a whole, the region will see a much larger decline in arrivals versus BAU (24.00%) from this scenario than under any other modeled scenario (even scenario nine which is considered the most impactful of the first 18). This is a decline by almost six times as much than the percentage decline indicated in scenario nine which should also be considered a challenge for the region that has been used to continuous growth from its tourism sector.

Clearly the conditions which represent the decrease in arrivals from the 'serious' scenario are most troubling for the Caribbean region, but a decline in growth by any standard is not advantageous for a region which is used to a steady growth in visitor arrivals - one projection shows BAU regional growth at 4% annually to 2014 (WTTC, 2004). Whether this sustained tourism growth and increased reliance on the industry is the best strategy for the region is a subject of debate and must be analysed with regards to the way the industry is concretely contributing to the prosperity and development of the nation and its people. The most significant decline (from the 'serious' scenario) is not probable in the time frame these results represent (i.e. up to 2020) largely because the necessary preconditions and political will for such drastic emission cuts on aviation do not appear to exist or are slow to progress. Even so, the 'serious' climate policy scenario of the model is an important situation to visualize since it is not out of the question that something similar will materialize post-2020 as policies which could inflict similar outcomes are currently under discussion at international research organizations (i.e.. the Tyndall Centre in the UK), and the commitment to reduction of emissions from the tourism industry is becoming more widespread (UNWTO et al., 2007; UNWTO et al., 2008; WTTC, 2009a).

Aside from the 'serious' climate policy scenario which undoubtedly has the most impact of those modeled in this thesis, there are other clear signals which are depicted in the scenarios' results. As has been shown, scenario nine would see the largest decline in regional arrival numbers versus BAU (-4.29% decline in 2020 versus BAU) while scenario ten would see the least impact on arrivals, although still projecting a decline of 1.28%.

4.2 Country Specific Results

It is important to understand how the Caribbean region as a whole is projected to be impacted by these different climate policy and fuel price variables but, since the region is made up of many sovereign states, understanding which of these which could be considered to be of high and low vulnerability under the scenarios is also important for future planning and opportunity scoping. To determine this, the percentage change between the BAU arrivals projected for 2020, and the arrivals projected in 2020 for the best case - scenario ten, a bad case - scenario nine, and for the worst case - the 'serious' climate policy scenario are presented (*Table 19)*.

Table 19 - Percentage Change in Arrivals in 2020 (versus BAU)

Destination	Arrivals in 2020 (BAU)	Scenario Ten (Best Case)		Scenario Nine (Bad Case)		Serious' Climate Policy (Worst Case)	
		Arrivals in 2020	% Change	Arrivals in 2020	% Change	Arrivals in 2020	% Change
Anguilla	186164	184009.12	-1.16%	180022.12	-3.30%	153212.12	-17.70%
Antigua and Barbuda	381562	377081.8	-1.17%	366771.9	-3.88%	305651.3	-19.89%
Bahamas	1815505	1779328.8	-1.99%	1690946.8	-6.86%	1036855.9	-42.89%

Barbados	565450	555561.08	-1.75%	530087.87	-6.25%	338742.17	-40.09%
Belize	420988	414536.9	-1.53%	398064	-5.45%	274644.2	-34.76%
Bermuda	152172	150265.54	-1.25%	146908.54	-3.46%	124823.44	-17.97%
British Virgin Islands	664891	657520	-1.11%	643151.3	-3.27%	548429.7	-17.52%
Cayman Islands	53128	52344.21	-1.48%	50581.17	-4.79%	37856.19	-28.75%
Cuba	5370324	5323645	-0.87%	5218754	-2.82%	4609235	-14.17%
Dominica	119150	118520.43	-0.53%	117257.9	-1.59%	109448	-8.14%
Dominican Republic	7334006	7239095	-1.29%	7006937.9	-4.46%	5528714.2	-24.62%
Grenada	117042	116018.471	-0.87%	113670.102	-2.88%	98480.528	-15.86%
Guyana	170294	168103.45	-1.29%	163404.7	-4.05%	130015.34	-23.65%
Haiti	69210	68336.48	-1.26%	66590.51	-3.79%	54493.32	-21.26%
Jamaica	2087811	2061194.1	-1.27%	2009960.1	-3.73%	1660019.1	-20.49%
Puerto Rico	5191358	5109553	-1.58%	4927857	-5.08%	3621670	-30.24%
St. Lucia	533961	528088.1	-1.10%	515448.3	-3.47%	437273.8	-18.11%
St. Vincent and the Grenadines	219440	217766.37	-0.76%	214165.49	-2.40%	191810.27	-12.59%
Suriname	4744193	4690308.1	-1.14%	4540422.1	-4.30%	3689098.1	-22.24%
Trinidad and Tobago	737139	727008.81	-1.37%	700964.89	-4.91%	518533.65	-29.66%
Turks and Caicos	469532	463855.6	-1.21%	454679.1	-3.16%	396708.7	-15.51%

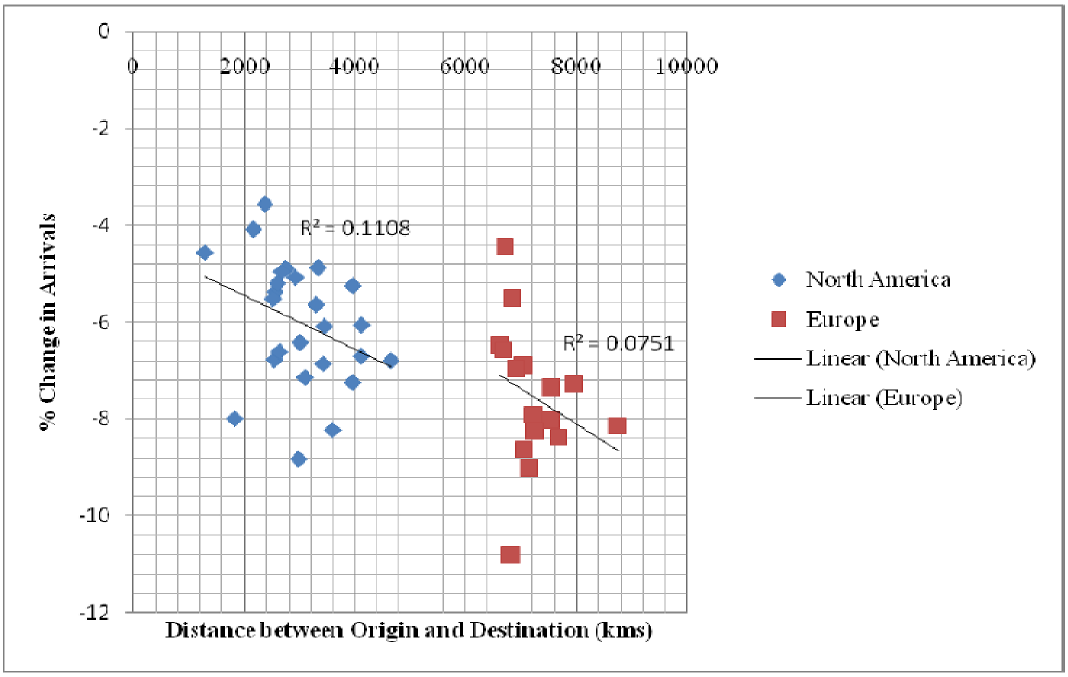
In all three of the scenarios shown Bahamas, Barbados, Belize and Puerto Rico are considered to be see the biggest decline while Dominica, St. Vincent and the Grenadines and Cuba are likely to be among the least impacted. Bahamas and Barbados are one and two in terms of most impacted for all three scenarios while, Belize is the third most impacted for scenario nine and the 'serious' climate policy scenario and fourth for scenario ten. Puerto Rico is the opposite of Belize, being third most impacted in scenario ten and fourth for scenarios nine and 'serious' climate policy. The least impacted are consistently Dominica, St. Vincent and the Grenadines and Cuba.

4.2.1 Significance of Major Source Markets

Since each of these countries have a unique source market (percentage from each origin country), it is interesting to look at how source markets will be impacted by the parameters modeled. The model focused on visitors who travel from countries in either the EU or NA and while this sometimes does not account for the total tourist arrivals to any given destination, these are the origin countries which will have the most impact, in the near future, on Caribbean destinations through heightened costs associated with air travel. These two main arrival markets have remained stable over most of the history of Caribbean tourism given their linkages to the island nations but also their relative convenience of travel. It is possible, though, that in the future, different source markets may become significant and the geographical pattern of origin-destination locations will be altered.

Some of the destinations modeled have a single origin making up the significant part of their arrivals while others have three or four (or as in the case of the Dominican Republic, six different locations). Because the cost of carbon is directly related to the emissions which are related to the distance traveled, it is not surprising that travelers from the EU tend to have a higher additional cost on their ticket and therefore are shown to be more impacted by the ETS policy and projections are that their arrival numbers will decline more than visitors from either Canada or the United States which travel a shorter distance. *Figure 13* illustrates the relationship between origin/destination and change in arrivals. Although the trend is stronger for NA arrivals, both groupings portray, in general, declining arrivals as the distance to destination increases.

Figure 13 - Distance Between Origin and Destination Country versus Arrivals Change for 2020 Scenario Nine



4.3 Scenario Specific Results

Although there were a total of nineteen scenarios modeled in this research, there are a smaller number which deserve to be highlighted more carefully. Scenarios nine, ten and 'serious' climate policy have already been discussed and will be detailed more in this section but in addition to these are those scenarios which provided results anomalous to what would be expected; scenarios 4,7,13 and 16.

The input parameters (see *Table 18*) into scenario nine intuitively indicate that the results will be the most negative (amongst the first eighteen modeled) for destinations since the parameters represent the highest price of both oil and carbon and the most elastic value used in the modeling is also inputted. The results show this is an accurate hypothesis and therefore the output from the different destination models matches what one would anticipate. Scenario ten, on the other hand, is as close to opposite of scenario nine as possible in this model; it models the reference (or low) oil price forecast, low cost of carbon and an elasticity value which indicates a smaller decline in demand versus BAU for any given increase in price. Of course, the 'serious' climate policy scenario is also representative of expectations with a much more negative outlook than any of the eighteen others but not likely to occur within the next decade.

In order to illustrate the change in arrivals for each destination, *Table 20*, details the percentage change versus BAU by destination for scenarios nine and ten as well as indicating whether any of the other seventeen scenarios showed deviance from a natural decline between scenarios one and nine and again between ten and eighteen. The reason that these two grouping exists is because they represent the two different future oil price forecasts; one to nine is modeled with a high oil scenario while ten to eighteen uses the reference oil scenario. The anomalies from a linear result that is shown in *Table 19* are detailed below and illustrated in *Figures 14 and 15.*

Table 20 - Destination Specific Scenario Results

	Best Case	***Value***	***Worst Case***	***Value***	***Anomalies***
Anguilla	10	-1.16%	9	-3.30%	4, 13
Antigua and Barbuda	10	-1.17%	9	-3.88%	4,7,13

Bahamas	10	-1.99%	9	-6.86%	-
Barbados	10	-1.75%	9	-6.25%	-
Belize	10	-1.53%	9	-5.45%	-
Bermuda	10	-1.25%	9	-3.46%	4,13
British Virgin Islands	10	-1.11%	9	-3.27%	4,13
Cayman Islands	10	-1.48%	9	-4.79%	-
Cuba	10	-0.87%	9	-2.82%	4,7,13,16
Dominica	10	-0.53%	9	-1.59%	4,13
Dominican Republic	10	-1.29%	9	-4.46%	4,13
Grenada	10	-0.87%	9	-2.88%	4,13
Guyana	10	-1.29%	9	-4.05%	-
Haiti	10	-1.26%	9	-3.79%	4
Jamaica	10	-1.27%	9	-3.73%	4
Puerto Rico	10	-1.58%	9	-5.08%	-
St. Lucia	10	-1.10%	9	-3.47%	4,13
St. Vincent and the Grenadines	10	-0.76%	9	-2.40%	4,13
Suriname	10	-1.14%	9	-4.30%	4,7,13,16
Trinidad and Tobago	10	-1.37%	9	-4.91%	-
Turks and Caicos	10	-1.21%	9	-3.16%	4,13

The Antigua and Barbuda chart (*Figure 14)* shows a destination which is projected to be impacted more strongly by certain input variables and therefore the output chart does not follow a linear trend downwards but instead has anomalies in its presentation. For example, scenarios four, seven and thirteen are anomalies with the remainder of the graph. This is in contrast to the Bahamas' chart (*Figure 15)* which shows a destination that has consistent change and shows a relatively homogenous and linear result for scenarios one to nine (those using the high oil scenario) and then ten to eighteen (those using the reference oil scenario).

Figure 14 –Antigua & Barbuda's Percentage Change in Tourist Arrivals for 2020 versus BAU (Scenarios 1-18)

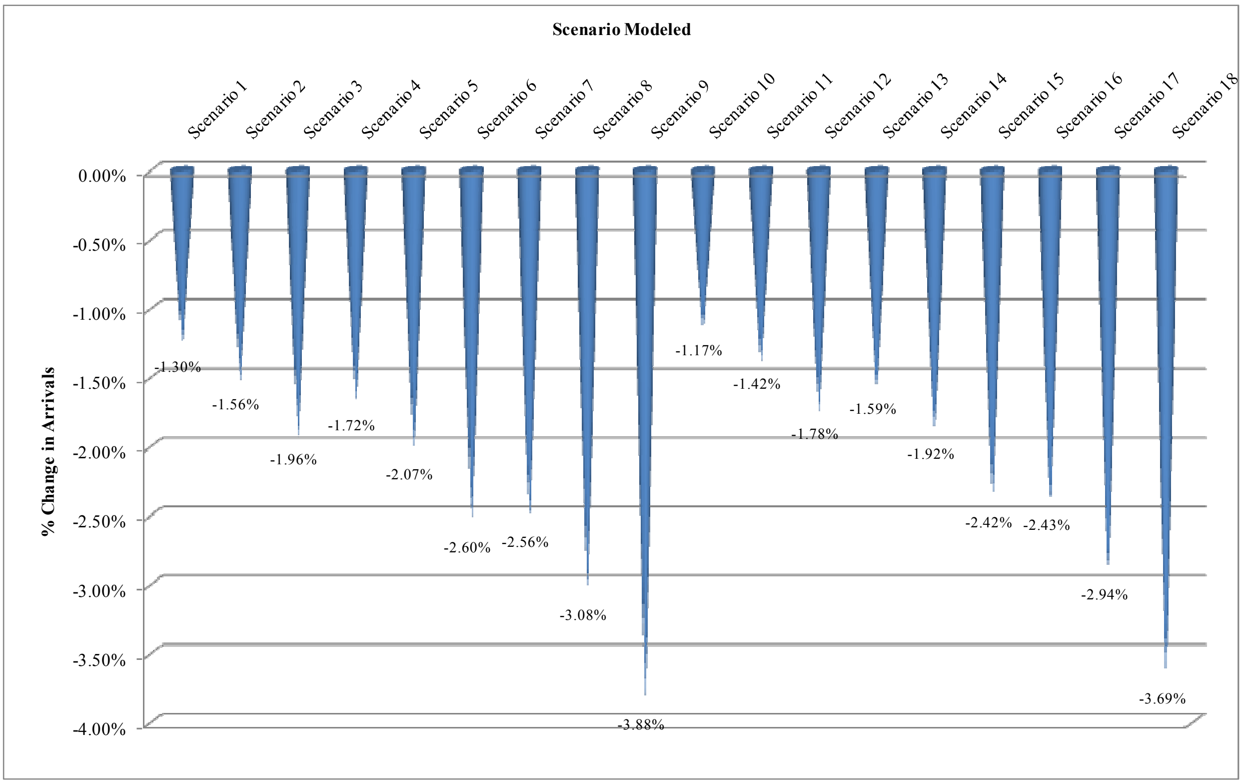
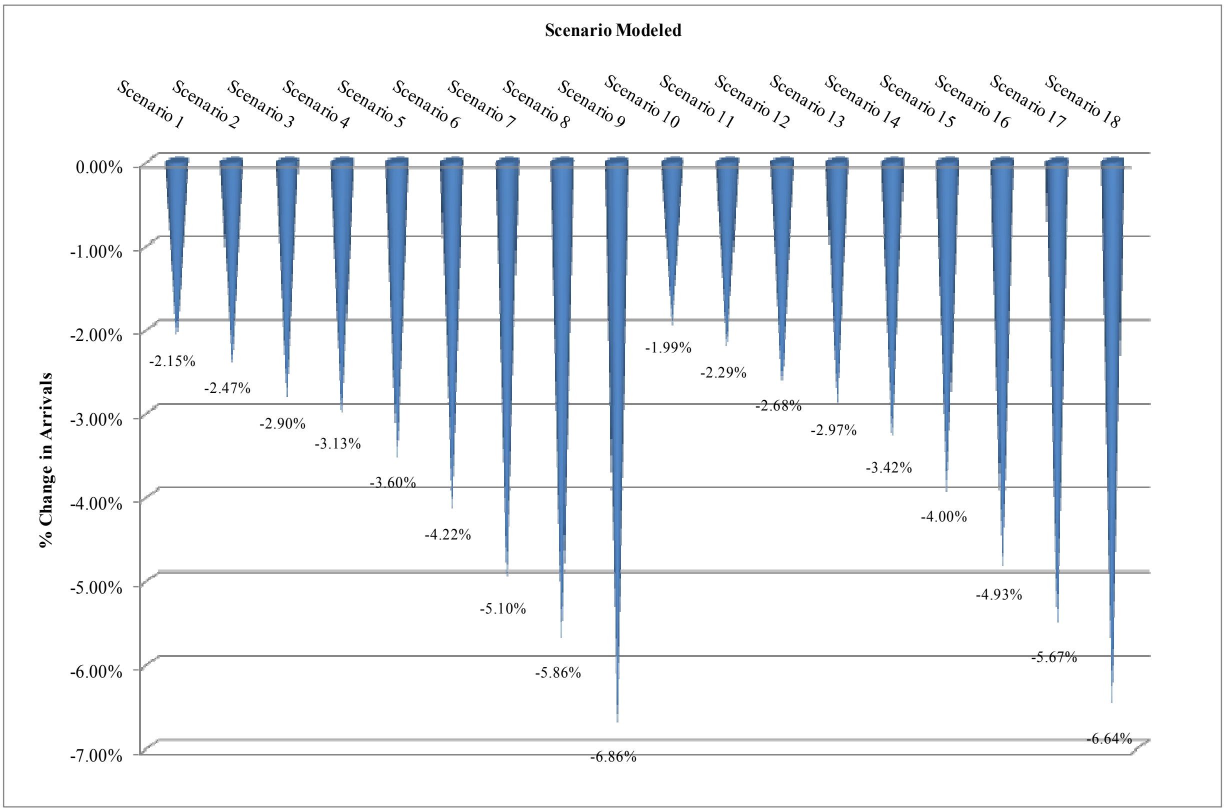


Figure 15 - The Bahamas' Percentage Change in Tourist Arrivals for 2020 versus BAU (Scenarios 1-18)



4.4 Range of Impacts from Variables

As is illustrated above, certain input variables had different impacts depending on which destination country was modeled. Four scenarios appear as anomalies several times within the entire set of results (*Table 20)*. Of these, scenario 4 showed anomalies most often; 14 times, and in every scenario which showed non- linear change. Coupled with this, scenarios 7 and 13 were also prevalent; appearing 3 and 12 times, respectively. Scenario 16 was also noted twice. Sixty-six percent of the modeled destination countries experienced a deviance from the anticipated linear result; the regional average also experienced similar output variance. The impacts that the different input parameters had on these variances are discussed below.

4.4.1 Price Elasticity and Carbon Price

All four of the scenarios mentioned are similar in that their variance from the norm was resultant from either an increase in the inputted carbon price (from \$16-\$31 or from \$31-\$61) or a decline in elasticity value entered. In each of the scenarios noted the elasticity value went from the more elastic value (-1.7 for the EU and -1.4 for NA) to the least elastic value (-1.04 for both areas) while at the same time the price of carbon increased (either from \$16-\$31 or \$31-\$61). This increase in price would intuitively mean that, *ceteris paribus,* the rate of growth would decrease; but in this case, the sharp change from a fairly elastic to a much less elastic value outweighs the cost increase and shows a slight increase in arrival growth rates. In the regional average output this anomaly only happens when the price of carbon goes from \$16-\$31 at both high and reference oil scenarios (scenarios 4 and 13); meaning that the change in carbon price from \$31-\$61 is strong enough to outweigh the decline in elasticity (scenarios 7 and 16). At the destination level though some of the results showed that the change in elasticity value outweighed the increase in carbon cost even when it went from \$31-\$61. This occurred in the high oil set of results (scenario 7) for Antigua & Barbuda, Cuba and Suriname and in the high reference oil set of results (scenario 16) for Cuba and Suriname. There were some destination countries though which did not have anomalies appear in their results at all and it is difficult to say the exact reason for this is, although distance from major origin to destination and the total proportion of arrivals that, in the end, were countries modeled to be impacted by the ETS are likely good indicators. What can be said though is that those destinations which experienced anomalies in not only scenario 4 and 13 but also 7 and/or 16 were located the farthest (or among the farthest) away from their overall significant origins. For example, even though Cuba draws about a quarter of its arrivals from Canada which is a relatively close origin, the other significant origins which were modeled in this research are numbers 1, 2 and 5 with regards to distance between origin and destinations – in essence this means more emissions and therefore a higher overall cost from the ETS component.

4.4.2 Oil Price

The input variable of oil price is based on projections for future cost in two different scenarios; reference and high. This is used as a representative of what jet fuel price will do in the same time frame. It is clear that the higher the oil price, the greater the reduction in arrivals expected at any given scenario. This is clearly depicted by the fact that scenarios 1 to 9 have lower growth rates attached to them than scenarios 10 to 18 which are the modeled exactly the same with the exception of the price of oil variable.

4.4.3 Overall Additional Cost to Air Travel

Understanding what changes in price give way to different degrees of change in tourist arrivals versus BAU is crucial in order to be able to see what magnitude of price change must occur for any of the given scenario outcomes. The scenarios which were modeled showed a range of additional cost from the variables inputted. The lowest extra added to a flight was \$2.05/ ticket for a roundtrip flight from the USA to Bermuda under scenario 10 (previously noted as the overall least impactful scenario) while the largest price increase reached \$39.69/ticket for a roundtrip flight from the UK to St. Vincent and the Grenadines under scenario 9 (the most impactful of the regular scenarios); there is obviously much variance between these values. This additional cost relies strongly on the climate policy and its set emission cap as well as the distance which must be traveled between the origin and destination. When those same origin-destination pairs, USA to Bermuda and UK to St. Vincent and the Grenadines, were looked at under the 'serious' climate policy scenario remarkable variance within one scenario is noted. The first pair, which continues to illustrate the lowest additional cost, would see an additional \$69.74/ticket while the second pair would see the largest increase in additional cost with an extra \$354.73/ticket. These larger additional costs are shown to be larger deterrents to travel with corresponding 18 and 35%, respectively, declines in arrivals in 2020 versus the BAU arrival numbers.

4.5 Chapter Summary

This chapter has presented the results that the research model has produced, both as regional as well as destination specific analysis. It was found that all scenarios modeled showed a decline in arrivals for the year 2020 versus BAU, although the percentage decline varied based on the scenario which was modeled. The 'serious' climate policy scenario showed the most significant decline in arrival numbers, but it is not probable that its results will come to fruition during the time frame of this study. Of the realistic scenarios, scenario 9 showed (in both regional and destination specific terms) the largest decline in visitor arrivals versus BAU while scenario 10 displayed the least impact. Although a linear trend could be expected for scenarios 1 to 9 and 10 to 18, this was not the case for many of the destinations nor for the overall regional results indicating that one of the input variables was stronger than others. It was shown that when the price elasticity value went from its most to least elastic, this variable overtook the increase in price of carbon. At the regional level this occurred only when carbon price went from its low to mid point (scenarios 4 and 13) while in some destinations this was also shown to occur with carbon price moving from mid to high levels (scenarios 7 and 16). The remaining chapters will discuss these results in more detail and determine what they may mean for the region as whole and for specific destinations as well. Recommendations as to future paths will also be made.

5.0 Discussion

Chapter four showed the outcomes of the model used in this thesis; it detailed how different countries are likely to be impacted by rising air travel costs as a consequence of climate policy which includes restrictions on international aviation but also with regards to the fluctuation of the global price of oil. This chapter will focus on more detailed discussions of the results and what they may mean for the region as a whole and the different destinations within it.

5.1 Combined Impacts on the Caribbean

The research and results which came out of this thesis are useful in helping the Caribbean region's tourism sector continue to thrive, but also to prepare them for the diverse impacts from a changing climate. Much has been written on how these predominately island nations will be impacted by the physical aspects of climate change and ways in which they can adapt and prepare for such issues (Caribbean Disaster Emergency Response Agency, 2003; Donner et al., 2007; McWilliams et al., 2005; Mimura et al., 2007; Tompkins, 2005) but less is known about how other effects of climate change, such as economic considerations, will affect the sector and therefore regional economies. Understanding the level of importance different variables associated with a changing climate (global oil, carbon prices and consumer demand) have on their own, but also when combined with other outside knowledge, will have is important as the region moves forward.

The modeling shows very clearly that global climate policy, global oil prices and consumer demand must be taken seriously. The combination of high oil prices (although the predicted 2020 value that was used in the model is still below the peak which the price of oil hit in mid-2008), a high cost of carbon and a high elasticity value results in the biggest decline in tourist air arrivals in the region versus BAU. This is of course without considering the 19th scenario, 'serious' climate policy, which depicts an even larger relative decline in arrivals for the region. Even assuming the most positive scenario, the region is still likely to experience a decline in arrival numbers compared to the BAU scenario for the same time period.

The results show a consistently negative projection for countries such as the Bahamas and Barbados due to their strong reliance on the tourism sector as a contributor to GDP (section 5.1.1), their relatively low level of charter tourist arrivals (5.1.2) and the model output which shows they are to be more severely impacted by climate policy and oil price changes than others. Puerto Rico shows signs of also being strongly impacted although its reliance on tourism as a contributor to GDP is less and therefore they are likely to have a slightly better ability to adjust.

In contrast, there are several countries which, although according to this research will see declines in annual growth from what has become common place, look to be the relative winners of the region; Cuba, Dominican Republic, Dominica, Jamaica and Bermuda are the main ones. Suriname also shows positive signs, but, as has been previously noted, the rate of growth its calculations were based on is clearly unsustainable and so therefore projections are likely not accurate enough to make any statements one way or another. *Table 21* illustrates the different outcome criteria and where the different destinations rank[43]. These results must then be looked at under the premises of understanding the most vulnerable to physical climate change.

Table 21 - Overall Impact Comparison Ranking

Destination	*Best Case Scenario Impact (1= worst)*	*Worst Case Scenario Impact (1=worst)*	*Serious Climate Policy Scenario (1=worst)*	*GDP Reliance on Tourism (1=most reliant)*	*Reliance on Charter Flights (1=least reliant)*
Anguilla	14	15	15	3	5
Antigua and Barbuda	13	10	12	2	1
Bahamas	1	1	1	4	8
Barbados	2	2	2	5	7
Belize	4	3	3	N/A	N/A
Bermuda	11	14	14	12	2
British Virgin Islands	16	16	16	1	6
Cayman Islands	5	6	6	8	1

[43] Red highlighting indicates a country considered to be one of the top three most impacted in this situation while blue indicates a country considered to be one of the three least impacted

Cuba	19	19	19	14	N/A
Dominica	21	21	21	10	9
Dominican Republic	7	7	7	13	11
Grenada	18	18	18	11	4
Guyana	8	9	8	N/A	1
Haiti	10	11	10	17	1
Jamaica	9	12	11	7	10
Puerto Rico	3	4	4	16	1
St. Lucia	17	13	13	6	3
St. Vincent and the Grenadines	20	20	20	9	1
Suriname	15	8	9	N/A	N/A
Trinidad and Tobago	6	5	5	15	1
Turks and Caicos	12	17	17	3	N/A

5.1.1 Gross Domestic Product (GDP)'s Reliance on Tourism

The Caribbean region is considered one of the most tourism-intensive regions of the world so it is not surprising that the countries within this region have a significant portion of their GDP tied up in their tourism sector (Bryan, 2007; WTTC, 2009b). Understanding which destinations are most reliant on tourism as a part of their economy is important when trying to predict which will be most significantly impacted by climate change as an overall. In order to do this, knowing the amount of a country's GDP which is tied up in the tourism sector is crucial; *Table 22* details the percentage of GDP which the tourism economy in each destination country is projected to represent in 2014[44].

Table 22 - Forecast for 2014: Travel and Tourism as a Percentage of GDP

Destination	***Tourism as a % GDP (2014)*** ***(WTTC, 2004)***
British Virgin Islands	95.20%
Antigua and Barbuda	93.90%
Anguilla	93.30%
The Bahamas	68.90%
The Barbados	59.30%
St. Lucia	58.90%
Jamaica	42.90%
Cayman Islands	38.30%
St. Vincent and the Grenadines	35.80%
Dominica	32.90%
Grenada	32.20%
Bermuda	30.20%
Dominican Republic	22.30%
Cuba	16.80%
Trinidad and Tobago	12.10%
Puerto Rico	6.30%
Haiti	5.50%
Belize*	
Guyana*	
Suriname*	
Turks and Caicos*	

* no data available

[44] These numbers are for total travel and tourism economy from the WTTC which is more all encompassing than total travel and tourism industry but is used as, at least for these countries, there is much linkage between the tourism industry and other parts of the economy so it is accurate to include them as they will be impacted as well.

This table indicates that the British Virgin Islands, Antigua and Barbuda and Anguilla are the most tourism dependent destinations with regards to the sector's contribution to overall GDP. None of these countries though were listed as the most impacted by the outcome of the research model which is good news as they do not appear have many other forms of economic stimulus to fall back upon. The fourth and fifth most tourism reliant destinations are Bahamas and Barbados which have both been shown to be in serious trouble due to declining visitor arrivals as a consequence of climate policy and future oil prices. Together, these projections (visitor arrivals and percentage of GDP reliant on tourism) paint a fairly dim picture for these two countries. Puerto Rico, also projected by the models to be among the most impacted destinations has the lowest reliance on tourism in the region (of those which data is reported for) and so therefore is likely to weather the downturn better than its counterparts.

5.1.2 Different Air Travel Options

Because this research focused on the arrival of tourists via air travel, it was necessary to understand the number of these arrivals associated with flights that were chartered or privately run. Chartered flights are assumed to be representative of flights which are included in package vacations and are usually operated by travel companies specializing in all-inclusive travel. This is an important distinction because the price elasticity value of a passenger on a charter flight is likely less elastic than a passenger on a commercial flight (Gossling et al., 2008). The main reason for this is that charter flights are paid for as a part of a total vacation package and so the consumer is not particularly aware of the actual cost of a flight. Therefore if a flight increases in cost it is not visible nor is it as significant when the entire vacation is considered as one. The model assumed commercial flight arrivals and therefore used more elastic values as the input parameter.

This assumption that charter flights are equivalent to those used in all-inclusive packages is confirmed by the data presented in *Table 23*. The Dominican Republic and, to a lesser extent, Jamaica and the Turks and Caicos have large portion of arrivals from charter flights; these destinations (primarily the former) are known as all-inclusive, budget travel locals whereby flights are operated through the same company that books and runs the entire trip. If information on Cuban air operators were available, it is reasonable to assume it would also have a high percentage of chartered fight arrivals. Understanding what percentage of total air arrivals to any given destination is chartered or private is critical in understanding how accurate the change in arrivals numbers modeled in this thesis is for that same country.

Table 23 - Percentage of Air Arrival Passengers Traveling via Charter or Private Plane

Destination	***% of Air Passengers Arriving by Charter or Private Plane*** ***(National Tourism Offices and Airport Authorities, 2004)***
Anguilla	3.80%
Antigua and Barbuda	0.00%
The Bahamas	7.38%
The Barbados	5.60%
Belize*	
Bermuda	0.07%
British Virgin Islands	4.31%
Cayman Islands	0.00%
Cuba*	
Dominica	7.80%
Dominican Republic	51.39%
Grenada	1.43%
Guyana	0.00%
Haiti	0.00%
Jamaica	13.49%
Puerto Rico	0.00%
St. Lucia	0.49%
St. Vincent and the Grenadines	0.00%
Suriname*	
Trinidad and Tobago	0.00%
Turks and Caicos	22.11%

* No Data Available

None of the countries with a significant proportion of arrivals associated with charter or private flights are among the most impacted by a decline in visitor arrivals versus BAU as shown in the modeled results nor do they appear to have economies which are among the most reliant on the tourism sector. The countries which have already been highlighted as most vulnerable to change in arrivals appear to rely largely on commercial (non charter) transport (i.e. Puerto Rico, Barbados and Bahamas) and so it can be said that the results from the model are in fact largely accurate in their impact on total air arrivals to those destinations.

5.1.3 Physical Impacts of Climate Change

Although this thesis is focused on the impact the Caribbean will feel from the economic effects of climate change policies, it is also important to consider how these play alongside projected physical impacts of climate change. As noted before, the Caribbean is made up of predominately SIDS which are thought likely to be the recipients of some of the most dire consequences from climate change (Belle & Bramwell, 2005; Burns, 2000). AR4 projects with high confidence that both direct and indirect impacts on tourism from climate change are likely to be predominately negative (Mimura et al., 2007). Some of the most concerning for the tourism industry are the forecast for sea level rise, heightened water stress and increasing extreme event intensity (Belle & Bramwell, 2005; Mimura et al., 2007). Because a significant portion of tourism infrastructure is located right along the coast, sea level rise is a concern for the region; not only because of damage to physical structure but also because of potential erosion of the beaches which are a large drawing factor for visitors (Belle & Bramwell, 2005). The close proximity that much of the tourism sector has to the shoreline (Mimura et al., 2007) increases its vulnerability to extreme events which are very destructive to infrastructure as well as to the desire of a tourist to visit. Even for Caribbean countries less dependent on tourism, extreme events are detrimental as they tend to destroy agricultural crops and other livelihoods. For example, in 2004, Hurricane Ivan devastated the island of Grenada and the two main agricultural crops of that region significantly enough that these crops are not projected to be fruitful again and contribute to national GDP for up to 10 years (OECS, 2004).

Water is a crucial resource to all in the Caribbean and the tourist industry is no exception; the tourism sector is a large consumer of this precious commodity and will be negatively impacted as the region is hit by a reduced amount under climate change (Mimura et al., 2007). This projected impact is largely as a consequence of variance in precipitation. Although increases in precipitation are thought to be likely in the wet season, they are unlikely to cancel out the decline in the dry season leaving a water deficiency for many of the countries (Mimura et al., 2007).

Each of these physical impacts will bring negative economic consequences for the region and especially for the tourism industry. The combined effects of reduced tourist arrivals because of less attractive weather conditions, loss of insurability for the tourism operators or increased cost of operations and rebuilding after extreme events are sure to be considerable. Even more serious is the potential of tipping points in ability or desire to reinvest and rebuild. Is there a point where the tourism operators are losing too much and are unable to sustain their business? Will reduced profitability mean that investors will be less willing to rebuild after a major storm? Will governments be able to justify increasing improvements and repairs in infrastructure for a declining industry? All of these are thresholds which the individual countries and, together, the region must grapple with in the coming years. In the end it will likely be the accommodation and activity operators who will have to reduce their prices, thereby cutting their profit margins and decreasing the amount of finances available for rebuilding or adapting to the changing climate as it is doubtful airlines will take the financial loss.

5.2 High Vulnerability Nations: Barbados and Bahamas

As can be deducted by looking at the above figures and tables, the two destinations likely to be most impacted are Barbados and Bahamas *(*see *Figure 8* for location). Barbados is dominated by visitors from the US, UK and Canada while the Bahamas receives more than 85% of its visitors from the US alone. Both nations showed a BAU growth rate of just above flat line, 0.81% for Bahamas and 0.21% for Barbados. In all three highlighted scenarios; 9, 10 and 'serious' climate policy, these two nations ranked first and second in decline of arrivals for 2020 versus BAU. Both are also among the more tourism-dependent nations in the region; projections show that by 2014 Bahamas will depend on the tourism sector for 68.90% of GDP and Barbados 59.30% (WTTC, 2004). To top this off, with regards to the number of air arrivals which this model covers (those which are not chartered or private flights), in the Bahamas, 92.62% of flights are commerical and even more in the Barbados, with only 5.60% being chartered or private flights; meaning the model is able to predict near 100% of arrivals to both destinations (National Tourism Offices and Airport Authorities, 2004). Together these factors portray a rather negative future for these two destinations, one which will need to be addressed sooner rather than later. For the Bahamas especially, impacts from sea level rise are a great fear – in a World Bank study on most vulnerable nations to sea level rise, this country was consistently noted among the most vulnerable to the many different impacts a rising sea level would inflict (Dasgupta et al., 2007). Barbados is also a relatively low lying nation but does gently rise from the coast (CIA, 2009a) and so therefore is not quite as susceptible to sea level rise. This serious consideration, plus a score of other physical impacts from climate change, will provide more challenges for these islands as they will require additional funding to repair, rebuild and eventually adapt to the changing climate; and this must all be done with less income as visitors are projected to travel to these locals in smaller numbers versus what might be expected under a BAU situation.

The good news for these two nations is that they are among the most likely countries in the Caribbean to be able to bounce back and adapt to economic and physical impacts on their nations. Both Barbados and Bahamas are considered by the United Nations Development Program's (UNDP) Human Development Index (HDI) to be among the top in the world (31st and 49th, respectively, of 177) and are considered nations with high human development (UNDP, 2005) which one can assume means their ability to survive and continue to develop is significant. Hopefully this HDI rating is indicative of the structure of the two nations as a whole (i.e. education, lack of corruption, infrastructure measures) and is not tied exclusively to their prosperity from tourism or else they may see their HDI rating fall and with it their ability to adapt as effectively.

5.3 Low Vulnerability Nations: Cuba, Dominica and Dominican Republic

While Barbados and Bahamas are faced with a very grim projection, some Caribbean countries appear to have a more optimistic future. Cuba, Dominica and the Dominican Republic appear to be in for smaller reductions in tourist arrivals versus BAU, rely more strongly on chartered flights, and have more diversified economies. The relatively smaller decline in arrivals numbers versus BAU for Cuba and the Dominican Republic may be, in large part, due to the strong portion of all-inclusive, bargain holidays they offer which make heightened air travel costs less visible. Dominica, on the other hand, has capitalized on eco-tourism and it is not a beach tourism destination. In fact it does not boast many beaches at all; instead the draw it has are the tropical forests, waterfalls and clear fresh lakes (Discover Dominica Authority, 2009). All three destinations also have a relatively low reliance on the travel and tourism economy as a portion of their GDP, meaning that if they see a decline in revenue they have other sectors to fall back on and therefore their adaptive capacity for dealing with the physical climate change impacts is less likely to suffer from a lack tourism infused of funds.

5.4 International Tourism and the Global Economic Crisis of 2008-2009

The 2009 global economic recession caused finance tightening, regular job loss, and governments scrambling to stimulate economies in order to set them back on the track to recovery; the G20 leaders met and formulated a plan to inject confidence back into the market in hopes that things would begin to rebound (CBC, 2009). At the same time, the Caribbean region was under tremendous stress as visitor numbers dropped, airlines cut flights to the region and those visitors who were still able to make the trip felt guilty about spending the money on something of a luxury when their colleagues, friends and family could not afford a similar excursion (De Lollis & Hansen, 2009; Vermond, 2009; World News, 2008). The downturn had radiating effects; hotel suppliers and shipping companies located in Southern Florida felt pressure as orders decreased (Hemlock, 2009), the CTO cancelled their annual Caribbean Conference on Sustainable Tourism (Travel Daily News, 2009) and employees at different hotel chains found themselves without a job (Richards, 2008). This downturn in visitor arrivals existed above and beyond what has been shown in the model for this thesis, meaning that the region began to experience conditions which may exacerbate the results this model displays.

5.5 Additional Considerations

While the impact on prices from oil and carbon cost is likely to be most significant and visible with regards to air travel, there are other aspects of a total vacation which will also be affected. The accommodation sector is bound to be impacted by fluctuating oil prices because 10-20% of an average Caribbean hotels' operating costs is associated with energy usage (Caribbean Alliance for Sustainable Tourism, 2001) and about 90% of energy used (in hotels and otherwise) is oil-based, most of which is imported (Bueno et al., 2008; Caribbean Alliance for Sustainable Tourism, 2001). This inclusion is important for future understanding but is likely to have less of an impact on growth of arrivals because the increased cost will be included in a holiday as a whole which has been shown to have a less elastic value attached to it (Ringbeck, Gautam, & Pietsch, 2009).

Another factor is the food served at tourist establishments, much of which is not produced on the islands so has to be brought in, and because of the vast majority of countries in this region which are islands, like visitors, food must either be flown in or brought in by sea. This will mean extra cost from increasing oil prices as well potentially paying for emission allowance if air and sea freight become regulated under climate policy scenarios, as they likely will.

Given that cruise ship arrivals are significant in the Caribbean region, future research should also include how fuel prices and climate mitigation policy impacts these numbers. Although, at present, climate mitigation policy does not include emissions from cruise ships, it is expected that most cruise tourists fly to and from their port of call which would therefore mean part of their vacation would be included under the aviation aspect of mitigation policy and therefore increase in cost. Understanding how this, and the potential for future cruise ship emission caps, impact arrivals to Caribbean islands will be necessary as the Caribbean seeks to fully understand the impact that climate mitigation policy will have on their tourism industry.

5.6 Uncertainties in the Model

The model used in this research allowed three of the inputs to vary based on scenario – price of oil (in percentage annual change form), price of carbon and price elasticity. Each of these, as well as the baseline growth rate for each destination, holds a degree of uncertainty. The values for the price of oil and price of carbon are based on forecasts and estimates made by academia and the industry themselves and therefore are as accurate as possible given the current global economic situation and the inherent volatility of both of these markets

Price elasticity for leisure air travel has been researched extensively but given the many parameters which go into determining this measure of demand, there is great variance in the values presented. The baseline growth rate for the different destinations also holds some level of uncertainty due to the limited time frame the calculation is based upon.

It appears that of the input parameters carbon price, oil price and price elasticity, the later in fact makes the biggest difference when it is changed. This goes to show that models such as this are not simply uncertain due to the inputs from forecasted market variables but also from the range of variables which are estimated by other academics. That is, even though there are many estimates of price elasticity that have been published and are readily used, there is still no agreed upon value and therefore the use of one may have a substantially different impact than the use of a second.

It should also be noted is that the results portrayed are likely conservative in their estimation of additional cost - and therefore change in arrival numbers - because the changes in price associated with future oil cost is not factored into the countries which are not significant origins (i.e. other Caribbean nations and nations in South-Central America). The inclusion of this would therefore add a cost, at some level, to all air arrivals (not just significant origin arrivals) since all flights rely on the same base fuel source. The reason for this is that in order to accurately include oil price changes for all origins, each country (even those with only one percent of arrivals) would have to be individually entered and put through the model. This is an interesting aspect that in future research could be added, but for the purpose of this thesis it was not done as the researcher was more focused on those countries which provide the bulk of air travel arrivals to the region.

5.7 Chapter Summary

This discussion chapter highlighted that the region is not only vulnerable to economic impacts from a climate policy but also physical effects from a changing climate. As well, different destinations will be impacted at different levels depending, in large part, on their dependence on tourism as a contributor to their GDP as well as the type of flight which regularly brings visitors. Not only must the region plan for a decline in numbers versus BAU due to the increased cost of air travel to and from their destinations and the subsequent decline in economic stimulus to the economy but with a decline in financial status comes a lessened ability to fund adaptation to the physical impacts of climate change that are projected to occur.

6.0 Recommendations and Conclusions

Having modeled potential outcomes for the Caribbean region with regards to tourist arrivals from air under a number of different scenarios and discussed the likely impacts, the following chapter will detail how these results can recommend different paths forward both for the sector as well as with regards to aviation's inclusion in climate policy. The results from this thesis could be used by the Caribbean region and specific destination countries in order to allow their people, economy and tourism sector to capitalize on future changes instead of being caught off guard by declining arrival numbers from increasing vacation costs.

While an obvious path forward would be to recommend economic diversification to the region so that they are not reliant on a sole industry for their prosperity, in the Caribbean region there are two main stumbling blocks with this plan. First, historically many destinations had a more diversified economy but with the change in overseas trading factors, the economies have become much more tourism-focused and are unlikely to turn back to other sectors (Bryan, 2007). For example, although Jamaica has been a tourism focused nation since the 1950's, prior to this time, agriculture and mining sustained the nation (Jayawardena, 2002). St. Lucia also, until recently, was a large producer of bananas (Jayawardena, 2002) and the Dominican Republic turned to tourism out of necessity when their traditional export industry of tobacco and sugar declined (Bryan, 2007). Other Caribbean nations have similar histories which have resulted in an increased reliance on the tourism sector. This change occurred for a lot of countries when their preferential treatment by former colonial nations with regards to market access was taken away (Bryan, 2007; Mimura et al., 2007).

Secondly, many of the Caribbean nations are in fact not able to diversify because they lack the resources and sometimes land base to do so (Belle & Bramwell, 2005). Much of the region suffers from limited water and the increased cost of ensuring soil fertility which act as barriers to a thriving agricultural sector (Mimura et al., 2007) and so therefore tourism is a logical sector to focus on.

Important to note is that if a country *is* able to diversify effectively it should be attempted in order that its level of vulnerability to tourism decline is decreased. And, even if tourism remains the focus of a nation's economic plan, it is still necessary to diversify within the sector and extend the sector to include and increase the relevance of those who are indirectly involved in tourism activities. While not severing dependence of tourism income, closer linkages between tourism and local production would help broaden the economic base. More local food production and crafting products, for example, would increase economic benefit from the same tourism numbers (Clayton, 2003).

6.1 Strategies to Reduce Vulnerability of Caribbean Tourism to Climate Policy

The underlying assumption of this thesis is that the Caribbean relies heavily on the tourism sector for its economic viability and any negative change to this sector will be a problem for the region. It has been shown that as a regional whole, given any sort of cost associated with climate policy in an origin country and oil price increase, the region will see declines in growth from the rates to which they have become accustomed. Out of this research, specific destinations which are projected to be most impacted (i.e. Bahamas and Barbados) and least impacted (i.e. Dominica and Cuba) have emerged.

Mass tourism is the dominant form of land-based tourism in the Caribbean region but it has become clear that the region has not diversified its product enough and is often looked upon as a homogenous area which may not be long able to maintain its global competitive edge and retain visitor numbers (Bryan, 2007). In fact, it has been shown that among Caribbean islands the cross-price elasticity (or substitutability) is high, 1.33 to 2.4 (Rosenweig, 1988); meaning that visitors would substitute one island for another relatively easily if prices were cheaper at one – this would not be the case if visitors did not assume they could receive the same experience at any island. This suggests that tourists would also substitute another region entirely, depending on price.

6.1.1 Regional Cooperation

Although the colonial powers which dominated the many Caribbean countries have departed for the most part, there still exists a division amongst many of the islands (Jordan, 2007). There is a competitive attitude that each is out for their own wellbeing, which generates an atmosphere of distrust in the region (Bryan, 2007). At a government level these attitudes may have declined somewhat because of intra-regional organizations such as CARICOM, but it still may cause problems. Regional partnerships in everything from marketing to disaster aid are essential and must be undertaken immediately to retain market share and prepare for the future (Bryan, 2007; Steinmetz, 2009). Key to this is the fact that Caribbean countries are generally thought of as a region by the rest of the world. For example, if an act of violence or crime is committed on one island, that negative stigma will often extend to the other islands even if they have no contact or are completely different (Bryan, 2007). Like it or not, the Caribbean countries are closely linked in the perceptions of tourists, and therefore in order to stand out as exceptional vacation spots they must embrace their linkage and use it to their advantage.

This regional cooperation can be accomplished by promoting the region as a cultural haven to the global community; a place where in one vacation a tourist can visit several islands and be exposed to different cultural and natural phenomena's. Of course there are infrastructure needs for creating this type of tourism; for example easy access between islands perhaps by high speed ferry or catamaran. This would require innovation and a new way of thinking but the region already has a few such opportunities on which to build this idea (i.e. in order to get to Anguilla most tourists take the 20 minute ferry from St. Martin) (Caribbean Islands, 2009). Such approaches are necessary in order to show the diversity within the region and to prove that in fact the different destinations have something to offer everyone.

6.1.2 Shift in Marketing Focus

The majority of tourists to Caribbean nations, at present, come from two distinct locals, NA and the EU (mainly the Western countries) (Bryan, 2007; Bueno et al., 2008). The close proximity of the first and the linkages to old colonial powers with the second are part of the reason for their dominance. It is clear though that as the global tourism sector opens up and prices rise, if destinations are not easily distinguishable, traditional visitors may choose to travel to a place that is closer to home and therefore cheaper, but provides the same experience as the traditional Caribbean destinations. This is particularly of concern with regards to European visitors as they have the Mediterranean coast in easy traveling distance and it can also provide the 'sunlust' tourism for which the Caribbean is known (Crouch, 1994). North Americans as well might opt for vacations to the American south or west to fulfill the desire for beach holidays. Strategies are needed in order that the Caribbean region remains a destination which draws visitors.

6.1.2.1 Intra-Regional Travel

Different parts of Caribbean region *are* unique. Cuba is not the same as Dominica which is not the same as Turks and Caicos and this is key to marketing the region to the rest of the world, a concept which has already been touched on, but also is important in encouraging Caribbean nationals to visit a different country than their own. Not only would this travel allow residents of the Caribbean to learn more about their neighbours and to reduce any animosity that still exists but, since this region is not likely to be among the early adopters of climate policy such as a CT or ETS, any flights which are required for this type of travel will not have that extra cost attached to them. Of course, the clear alternative is transportation via the sea in a sustainable craft which would then not have to worry much about increases in oil price or the cost of carbon in the event a global climate policy is implemented. Given this, individual destinations should turn at least some of their attention away from marketing to the long-haul international destinations (and let a regional body do that) and instead focus on marketing to their fellow Caribbean nations.

6.1.2.2 Extended Stay Tourism

It is undeniable that in order for the Caribbean to be a popular tourism destination air travel is needed (Abeyratne, 1999; Bryan, 2007) but with that comes the fear of policies which will increase costs for this form of transportation and because, currently, the region is known for cheap vacation prices there is sure to be some backlash and a subsequent decline in arrivals versus BAU. The concept of an extended vacation is one which is becoming more popular amongst researchers who are attempting to reduce the environmental impact and energy intensity of tourism (Becken, 2002; Gossling et al., 2005). Unfortunately this type of tourism is in contrast to the current trend of shorter vacation length (Alegre & Pou, 2006), but if this trend cab be changed, a longer stay would be useful with regards to reducing the weight that the cost of a flight has as a part of a long-haul vacation. For instance, visitors who are staying for at least two weeks in an area will not have their flight accounting for 1/3 of their trip cost, but likely it will be substantially less, making the increase in the vacation not seem to rise as substantially in the wake of climate policy and its impacts on air travel. If the price of accommodation goes up (due to the percentage of operating cost reliant on oil) and with it the price of food (which for most Caribbean nations is flown or shipped in) the entire vacation will increase in price relative to the increase in the cost of oil. In addition, although packaged vacations are often thought of with regards to mass tourism and all inclusive vacations (as we can see by the number of charter flights going to the popular all inclusive destinations) (National Tourism Offices and Airport Authorities, 2004), their use for emerging types of vacations (i.e. extended stay or carbon neutral) may be beneficial to the region in the event prices increase since international tourism as a whole has a lower price elasticity (one meta-analysis puts it at -0.87 (Crouch, 1995) than simply international aviation and so therefore increases in flight costs may be disguised by including them together with the other costs of a vacation.

6.1.2.3 Emerging Markets

With the emergence of new markets such as China and India as well as some of the more developed South American countries there are new places for the Caribbean region from which to draw visitors. While both China and India are long-haul markets and therefore would be impacted by changes in oil price, in the near future they are not likely to implement climate policy which would impact aviation through carbon costs and so therefore the flight aspect of the vacation would not be impacted as much as if is visitors originated in NA or EU. The South American countries, though, are an excellent source of tourists for the Caribbean region since they are close by and therefore less likely to see significant increases in travel costs in the coming years. In fact, countries such as Cuba and Suriname already see some visitors from South American countries.

6.1.2.4 Carbon Neutral Tourism

There has been much talk in the recent past about carbon neutrality, with some destinations such as Sri Lanka and Scotland aiming for carbon neutrality and other individual tourist operators and hotels also striving to achieve this goal (Gossling, 2009). Tackling the issue and promising to offset and reduce the emissions which are to be so harmful to them in the future sends a very clear message to the global community and visitors that they should not introduce policy that will harm the region's economic mainstay, tourism. It also shows that visiting this region should not inflict 'traveler's guilt' and can reassure visitors that they are not contributing to the global warming by taking a vacation to the region. Making the region a carbon neutral destination will, no doubt, take time and money. It is likely that some countries will achieve it sooner than others because of their relative resources, showing that again regional cooperation is key. It is probable that this shift from mass tourism to a more diverse, carbon neutral tourism product will initially result in a decline in visitors since it may be a bit more expensive than the standard sun, sea and sand vacation but, as the market becomes more defined, visitors will begin to come back to the region and will boost this sector's market share again. Inclusion of an educational component could serve not only to teach visitors about climate change and how it is likely to impact the destination they are visiting, but also show them what the country and region are doing to ensure that the tourism sector is contributing as minimally as possible . Opportunities for tourists to participate in carbon offsetting (i.e. planting of trees) or to see some offsetting projects in action (i.e. solar panels on hotels they are staying at) will make the experience more authentic and help alleviate traveler's guilt.

It is not necessarily true that getting rid of the traditional Caribbean vacation must happen, it is possible that such a niche becomes what some of the islands are known for (as they already are) but that it is done in a different way so that sustainable practices and carbon neutrality can also be achieved in these areas.

6.2 Aviation and Climate Policy

While climate policy is essential to curb GHG emissions and slow the rate of climate change, it must be undertaken with caution and with a full understanding of the impacts it will inflict on different regions of the world. In the past, suggestions to curb emissions and overall environmental impact from aviation has focused on substitution of transport modes to non-motorized or to simply traveling locally (Hoyer, 2000). For regions such as the Caribbean this is not a plausible option if they are to continue as a international tourism destination (Becken, 2002). Inclusion of aviation under such a global policy is necessary, but it must be done in a way that it impacts the unnecessary flights more than those which are rely upon air travel tourist arrivals for economic stability. Simpson et al. (2008) note that policy which includes international aviation but which also provides preferential treatment for flights and aviation routes which aid tourism in developing countries is the ideal path to take. A study done by Becken (2007) shows that there is belief climate policies should differentiate between the different kinds of air travel; that business travel should be impacted more than leisure and short-haul more than long. It has also become clear that developing countries, particularly SIDS, rely on air travel to bring visitors (even if the visitors arrive via cruise ship most are flown to the departure port before boarding the ship) and without such transportation option these countries would suffer immensely. Short-haul flights which can be easily substituted by high speed train or coach services are those which should be targeted more strongly as there are alternatives for such travel and less often are they supporting a developing country.

6.3 Conclusions

This thesis examined the impact of climate policy and future oil price on long-haul tourism air arrivals to 21 Caribbean countries. The research addressed a knowledge and information gap that neither academia nor the Caribbean nations themselves had yet evaluated. The model used to determine the impact (change in air arrival numbers for 2020) was based partially on a previous study by Gossling et al (2008) which looked at changing arrivals for a select group of developing states, five of which were located in the Caribbean. This model added a regional understanding of this issue, and included the cost of oil in its forecast, a broader range of price elasticity values and modeled the ETS over both the EU and NA; which was not previously undertaken.

This thesis had four main objectives: to examine literature on the core topics of climate change, tourism and aviation; to analyze destination level arrivals data for the Caribbean region; to model this data along with criteria that was extracted from the review of literature in order to determine potential projections for Caribbean tourist arrivals from air for 2020 and to provide recommendations to the region and specific destinations on how to move forward given the projections displayed. Each of these, in turn, was addressed in specific chapters (two; three and four; five and six, respectively) but as well the outcomes were weaved together throughout the entire work.

The most important goal of this thesis was to provide the Caribbean region with a projection for what their arrival numbers (from air travel) might look like in 2020 after climate policy (in this case an ETS) which covers international aviation was put in place by countries which provide a significant number of visitors to the region. This projection was achieved by implementing a model which took into consideration arrivals data, growth in the aviation sector, annual aviation efficiency, price elasticity, emission rates and of course climate policy and its corresponding carbon costs as well as future oil prices. All variables were held constant with the exception of the cost of carbon, oil price and price elasticity values which were altered in order to determine the worst and best case scenario for the region as well as impacts on specific destinations. Nineteen scenarios were modeled, 18 of which represented 'reasonable' projections of what may occur in the time between present and 2020; the nineteenth was considered a 'serious' climate policy and is not expected to be accurate until after the 2020 modeling time period, if at all. The climate policy and volatile oil prices projected in the model increased the cost of a round trip ticket from a given origin to destination by between \$2.05 to \$354.73 which corresponded with declines in arrival numbers of 1.53% to 35% below a BAU scenario in the year 2020. On a regional whole, the best case was shown after modeling scenario 10 (which had the lowest cost of carbon, oil and least elastic value inputted) and indicated a change in arrivals of -1.28% in 2020 versus BAU while the worst case (the 'serious' climate policy scenario which inputted a social cost of carbon, more drastic emission cuts and a combination of reference and high oil scenarios using a mid-point elasticity value) gave way to a change of -24.00% versus BAU in arrivals for the same year. Results also indicated that there were significant differences between destinations with regards to arrival number changes; least vulnerable in this case were places such as Dominica and Cuba while on the other end of the scale sat the Bahamas and Barbados.

Given that, even under the best scenario (scenario 10) a decline in arrival numbers versus BAU is bound to be seen, steps must be taken to ensure the prosperity of the region's tourism sector. The overarching recommendation this thesis made was for regional cooperation with regards to tourism policy and planning but also climate change monitoring, adaptation and mitigation. Given the close proximity to each other and the fact that the countries are to be impacted in very similar ways by both physical but also economic consequences of climate change, the region must band together to reduce the impacts in whatever way possible.

6.3.1 Limitations

This research was only able to model how increases in cost to air travel would impact arrival numbers to different Caribbean countries but it is important to note that it is not only the air travel component of the vacation which would likely be impacted, especially in the Caribbean. The accommodation portion of a vacation is likely to become more expensive as well since it is a large user of energy; 10-20% of an average Caribbean hotel's operating costs are associated with energy

(Caribbean Alliance for Sustainable Tourism, 2001). This is in large part due to the fact that the Caribbean region is a net importer of oil and about 90% of energy used (in hotels and otherwise) is obtained from this oil (Bueno et al., 2008). The food services aspect of a vacation is likely in the future also to become more expensive as both air and water freight are monitored and taxed for emissions and the cost of their fuel increases. Both of these should be considered in future research, although their impact is expected on vacation cost increase and subsequent decline in arrivals is expected to be less than the impact of air travel as shown in this research. Data restrictions did not allow these other two parameters to be taken into consideration.

Another limitation is that there were destinations which had BAU growth rates which seemed unsustainable; namely Suriname which had an average annual growth rate of over 25% from 2000-2005. Suriname was still included in the regional calculations as it was proven that its removal did not alter the overall results considerably. Given this somewhat extreme growth rate though, removing Suriname would show a somewhat worse future for the region as a whole with regards to arrivals in 2020.

6.3.2 Future Research Needs

This thesis should be considered the ground work for future research and modeling in the area of economic impacts on the Caribbean (and other tourism reliant locations) from climate policy. In order to get a more complete understanding of the overall impact on the region from such policy and the volatile oil prices a model which includes accommodation (to understand how changes in oil price impact the price of this aspect of tourism), food miles (since much of the food served and used in the tourism industry is imported either via air or sea) and cruise ship arrivals (no doubt marine vessels will soon be included in climate policy themselves) is necessary. Together this would give an overall understanding of what, in fact, is possible in the region for the years to come.

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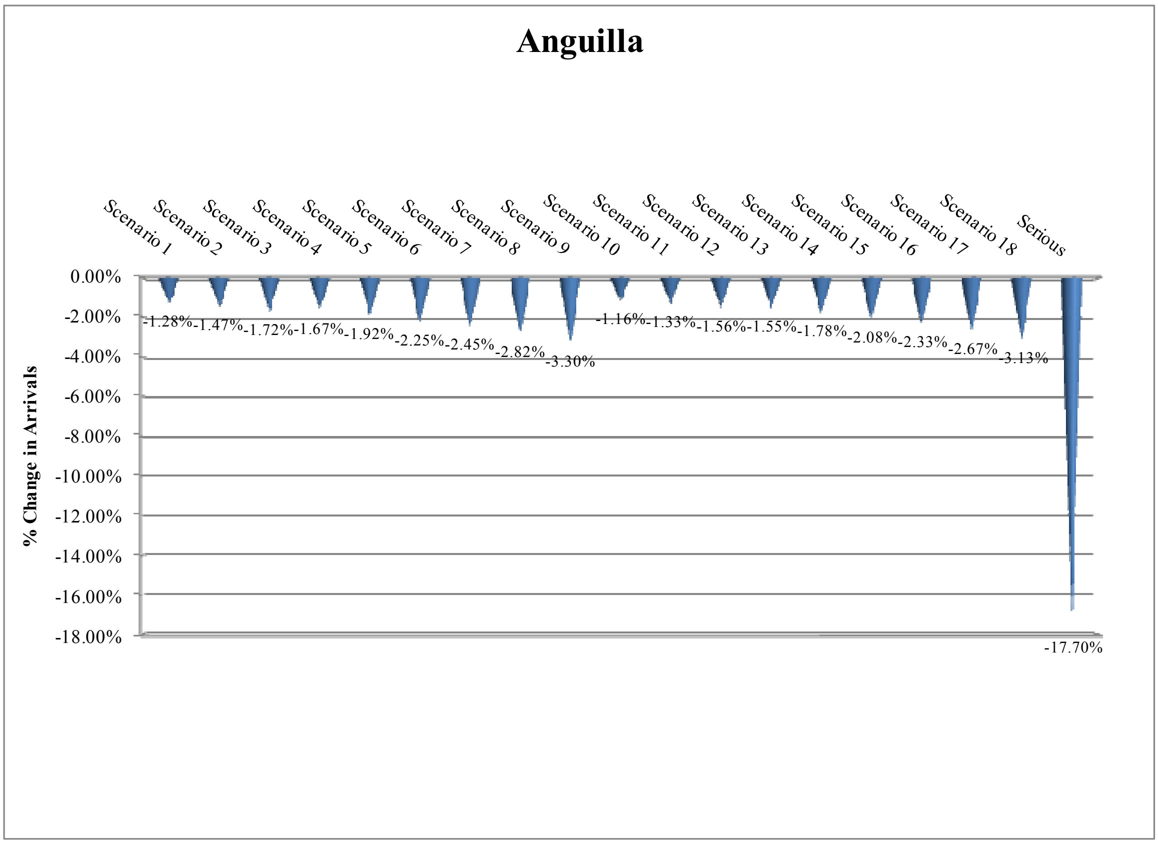
APPENDICES

Appendix A: Destination Level Arrival Changes Versus Business as Usual (BAU) for 2020



Anguilla
% Change in Arrivals
0.00%
-2.00%
-4.00%
-6.00%
-8.00%
-10.00%
-12.00%
-14.00%
-16.00%
-18.00%
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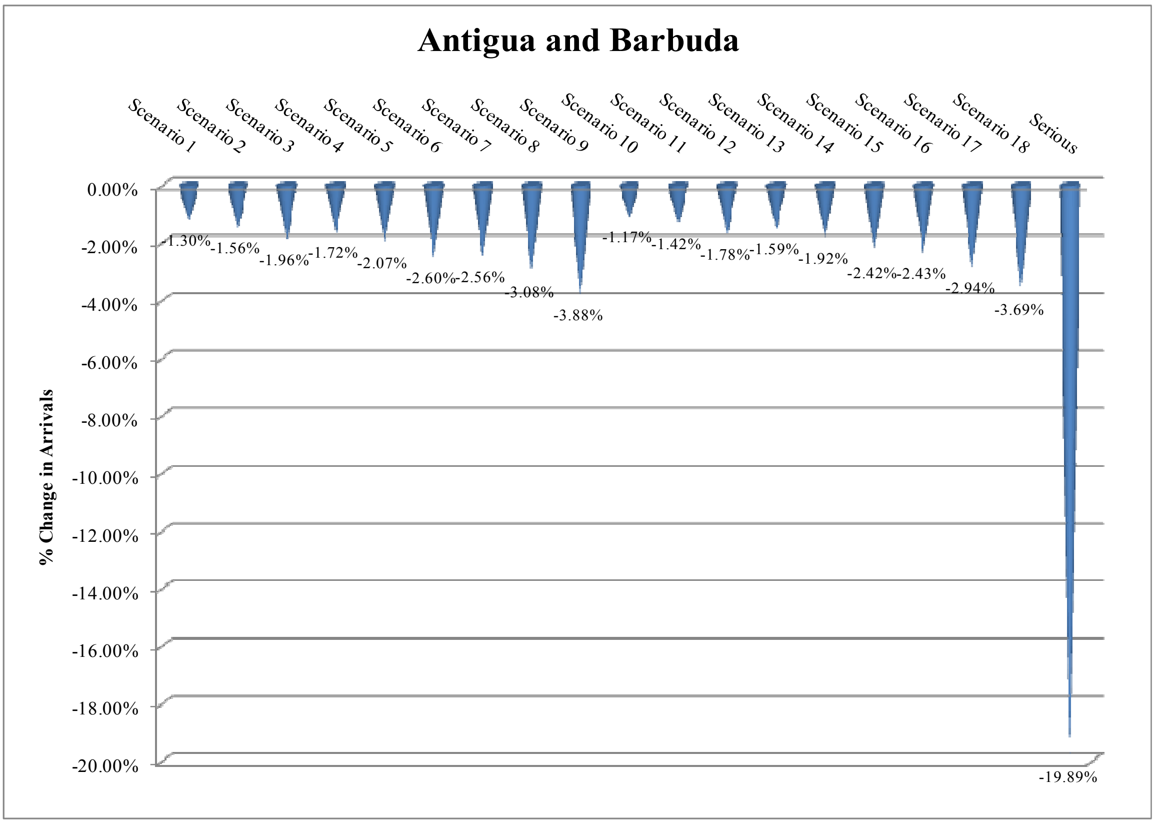
Scenario 14
Scenario 15
Scenario 16
Scenario 17
Scenario 18
Serious
-1.28%
-1.47%
-1.72%
-1.67%
-1.92%
-2.25%
-2.45%
-2.82%
-3.30%
-1.16%
-1.33%
-1.56%
-1.55%
-1.78%
-2.08%
-2.33%
-2.67%
-3.13%
-17.70%



Antigua and Barbuda
% Change in Arrivals
0.00%
-2.00%
-4.00%
-6.00%
-8.00%
-10.00%
-12.00%
-14.00%
-16.00%
-18.00%
-20.00%
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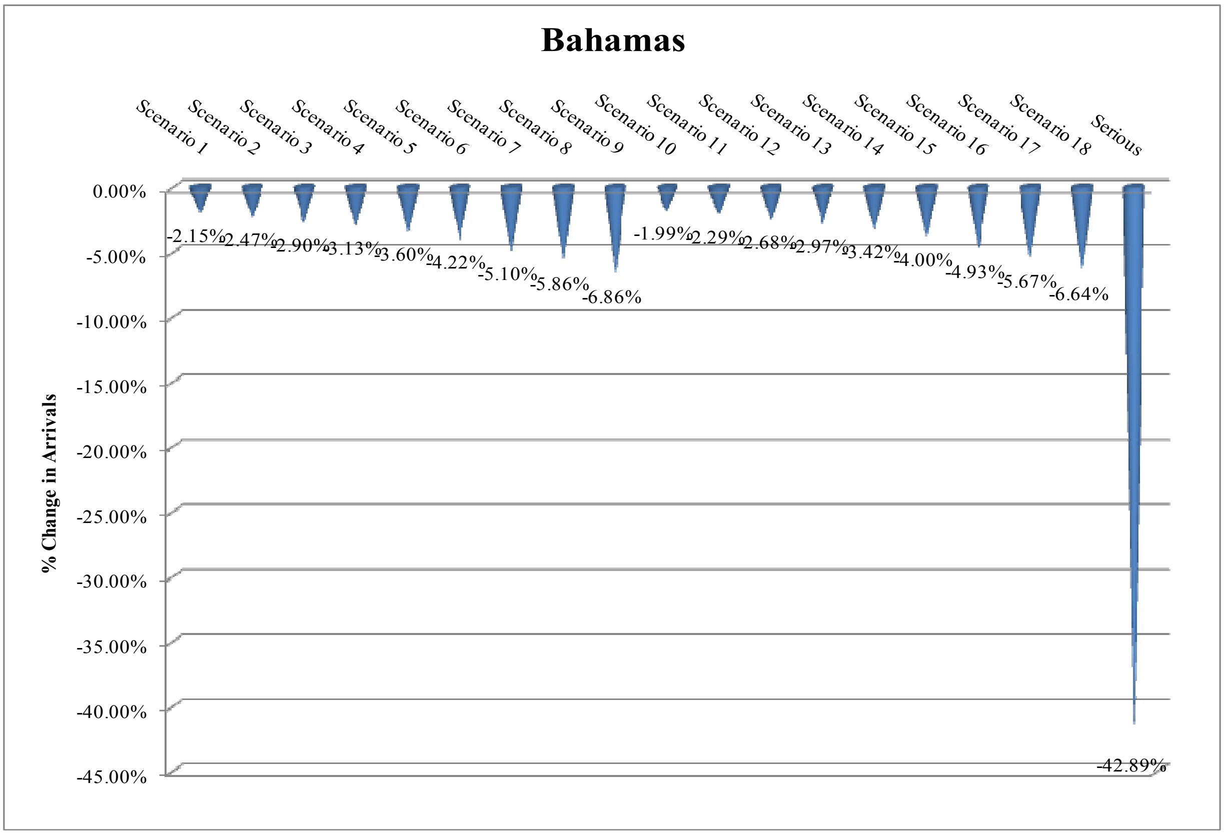
Scenario 6
Scenario 7
Scenario 8
Scenario 9
Scenario 10
Scenario 11
Scenario 12
Scenario 13
Scenario 14
Scenario 15
Scenario 16
Scenario 17
Scenario 18
Serious
-1.30%
-1.56%
-1.96%
-1.72%
-2.07%
-2.60%
-2.56%
-3.08%
-3.88%
-1.17%
-1.42%
-1.78%
-1.59%
-1.92%
-2.42%
-2.43%
-2.94%
-3.69%
-19.89%


Bahamas
Scenario 1
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Scenario 4
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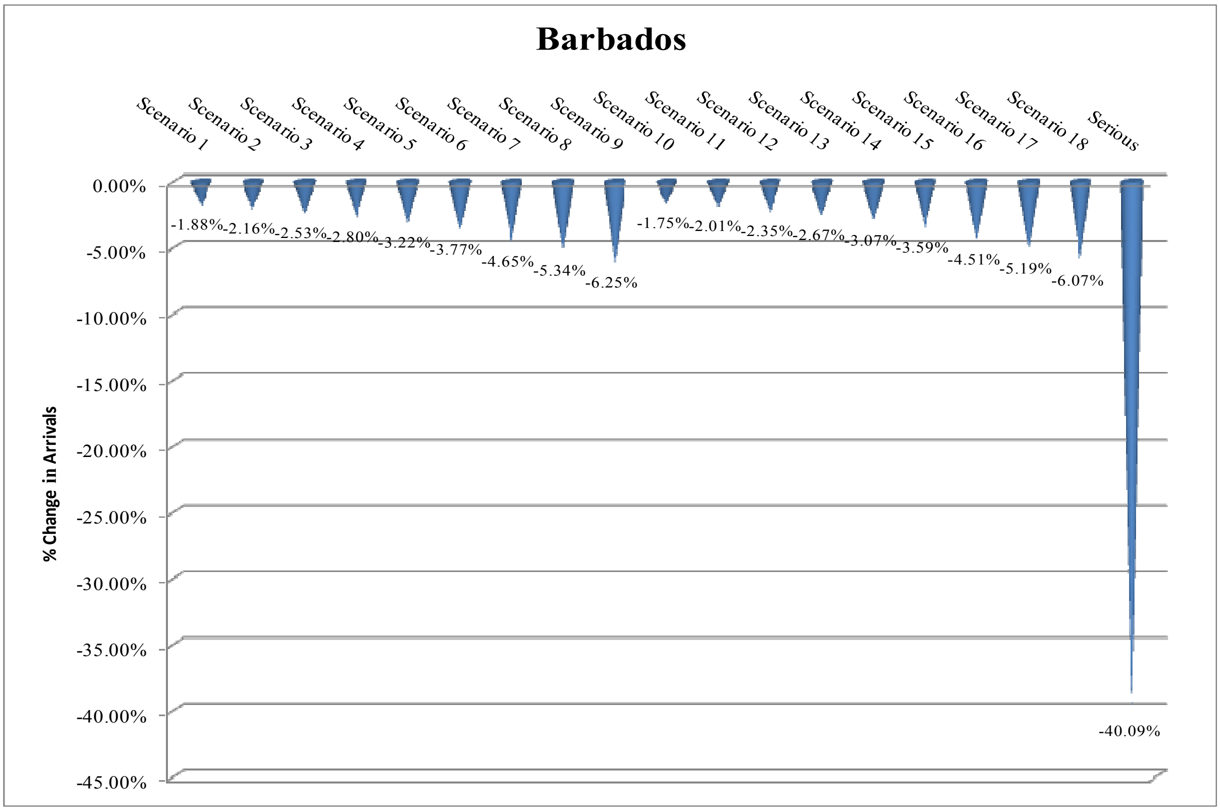
Scenario 7
Scenario 8
Scenario 9
Scenario 10
Scenario 11
Scenario 12
Scenario 13
Scenario 14
Scenario 15
Scenario 16
Scenario 17
Scenario 18
Serious
% Change in Arrivals
0.00%
-5.00%
-10.00%
-15.00%
-20.00%
-25.00%
-30.00%
-35.00%
-40.00%
-45.00%
-2.15%
-2.47%
-2.90%
-3.13%
-3.60%
-4.22%
-5.10%
-5.86%
-6.86%
-1.99%
-2.29%
-2.68%
-2.97%
-3.42%
-4.00%
-4.93%
-5.67%
-6.64%
-42.89%


Barbados
Scenario 1
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Scenario 3
Scenario 4
Scenario 5
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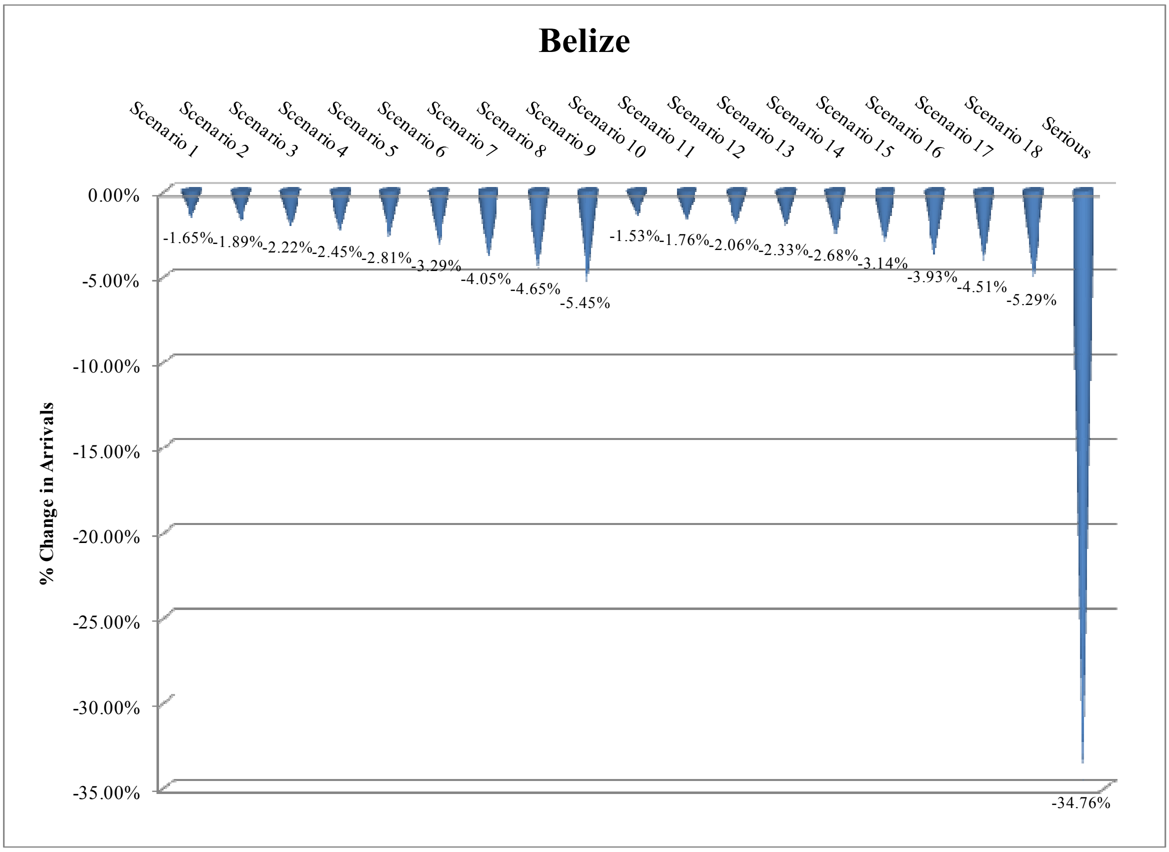
Scenario 7
Scenario 8
Scenario 9
Scenario 10
Scenario 11
Scenario 12
Scenario 13
Scenario 14
Scenario 15
Scenario 16
Scenario 17
Scenario 18
Serious
% Change in Arrivals
0.00%
-5.00%
-10.00%
-15.00%
-20.00%
-25.00%
-30.00%
-35.00%
-40.00%
-45.00%
-1.88%
-2.16%
-2.53%
-2.80%
-3.22%
-3.77%
-4.65%
-5.34%
-6.25%
-1.75%
-2.01%
-2.35%
-2.67%
-3.07%
-3.59%
-4.51%
-5.19%
-6.07%
-40.09%


Belize
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
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Scenario 9
Scenario 10
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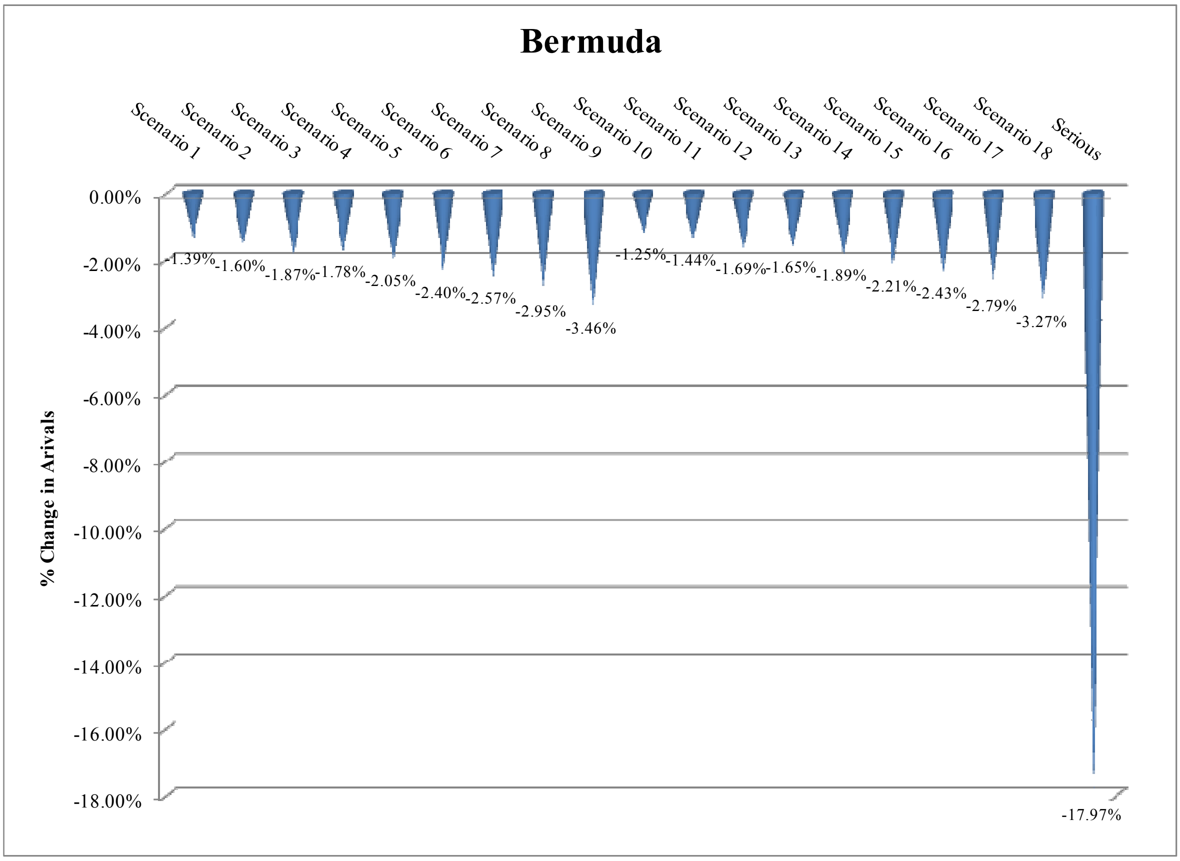
Scenario 14
Scenario 15
Scenario 16
Scenario 17
Scenario 18
Serious
% Change in Arrivals
0.00%
-5.00%
-10.00%
-15.00%
-20.00%
-25.00%
-30.00%
-35.00%
-1.65%
-1.89%
-2.22%
-2.45%
-2.81%
-3.29%
-4.05%
-4.65%
-5.45%
-1.53%
-1.76%
-2.06%
-2.33%
-2.68%
-3.14%
-3.93%
-4.51%
-5.29%
-34.76%


Bermuda
Scenario 1
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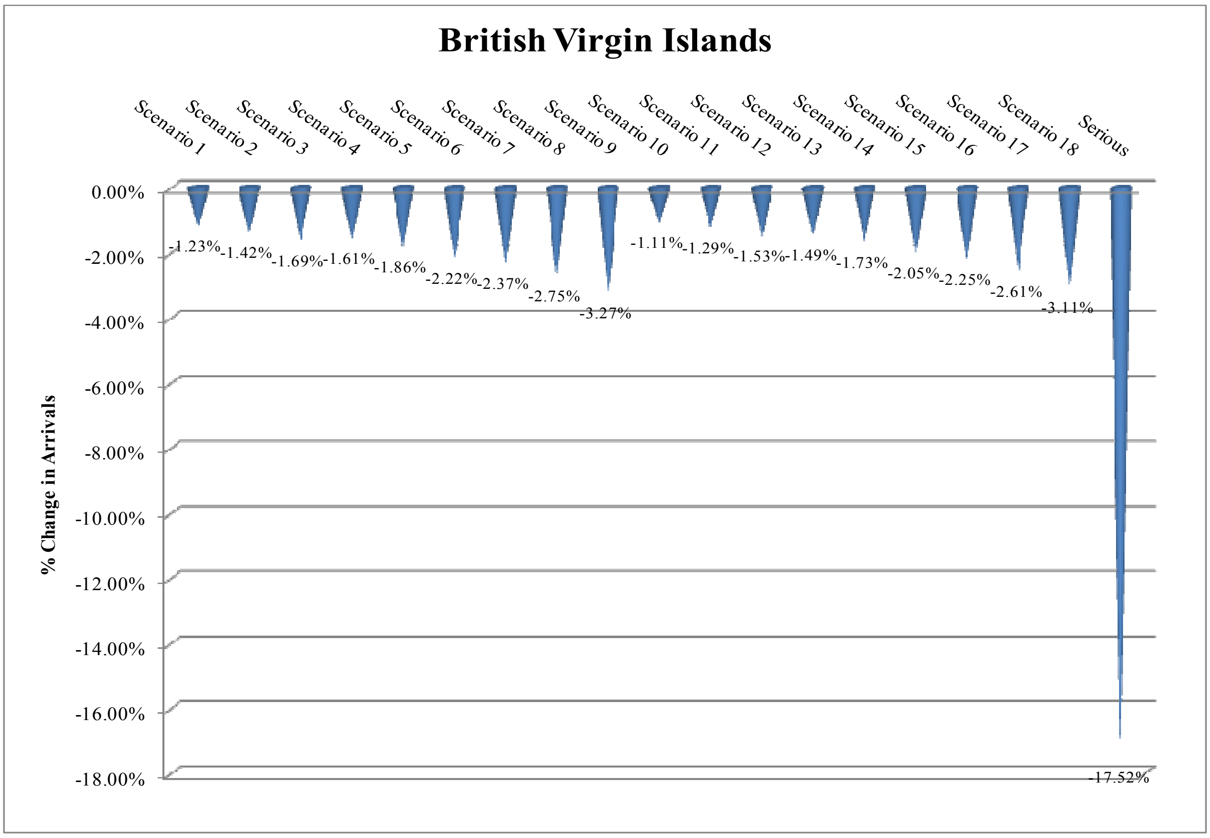
Scenario 14
Scenario 15
Scenario 16
Scenario 17
Scenario 18
Serious
% Change in Arivals
0.00%
-2.00%
-4.00%
-6.00%
-8.00%
-10.00%
-12.00%
-14.00%
-16.00%
-18.00%
-1.39%
-1.60%
-1.87%
-1.78%
-2.05%
-2.40%
-2.57%
-2.95%
-3.46%
-1.25%
-1.44%
-1.69%
-1.65%
-1.89%
-2.21%
-2.43%
-2.79%
-3.27%
-17.97%


British Virgin Islands
Scenario 1
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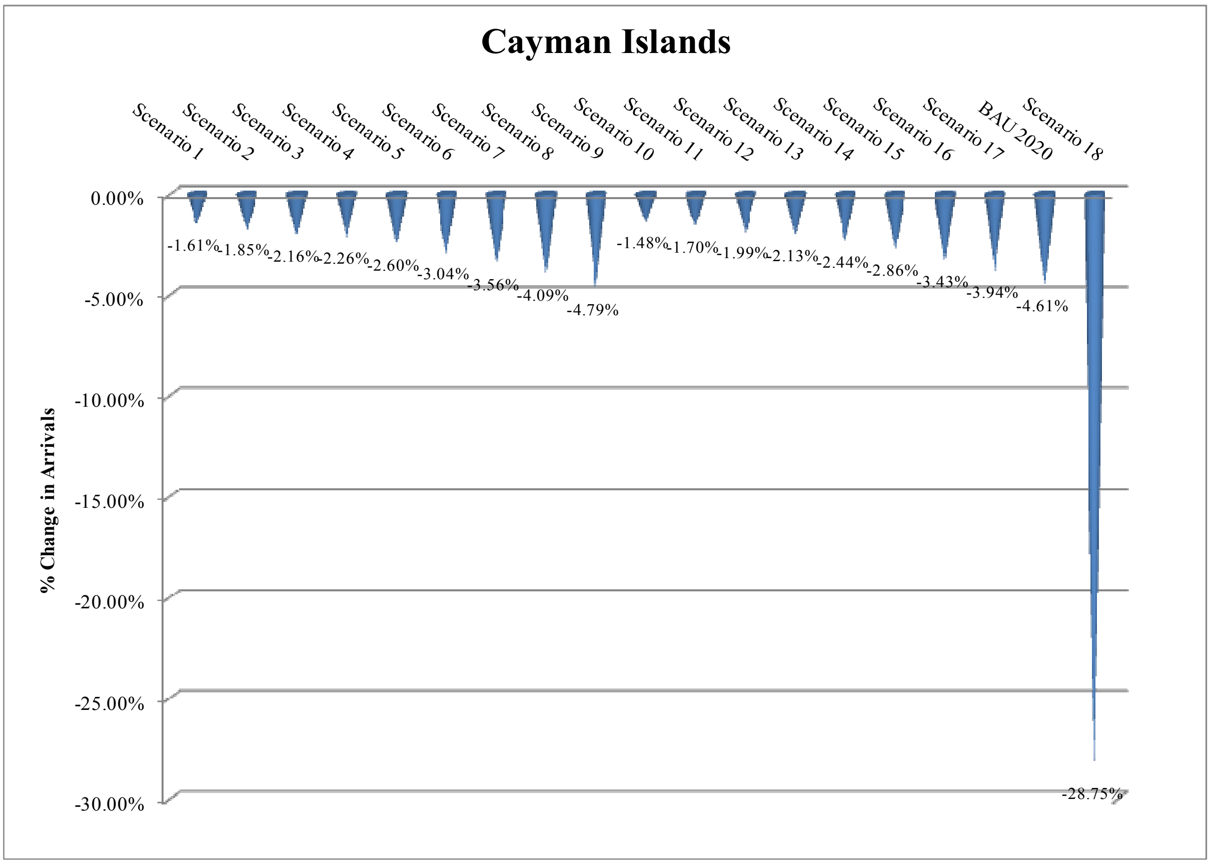
Scenario 9
Scenario 10
Scenario 11
Scenario 12
Scenario 13
Scenario 14
Scenario 15
Scenario 16
Scenario 17
Scenario 18
Serious
0.00%
-2.00%
-4.00%
-6.00%
-8.00%
-10.00%
-12.00%
-14.00%
-16.00%
-18.00%
% Change in Arrivals
-1.23%
-1.42%
-1.69%
-1.61%
-1.86%
-2.22%
-2.37%
-2.75%
-3.27%
-1.11%
-1.29%
-1.53%
-1.49%
-1.73%
-2.05%
-2.25%
-2.61%
-3.11%
-17.52%


Cayman Islands
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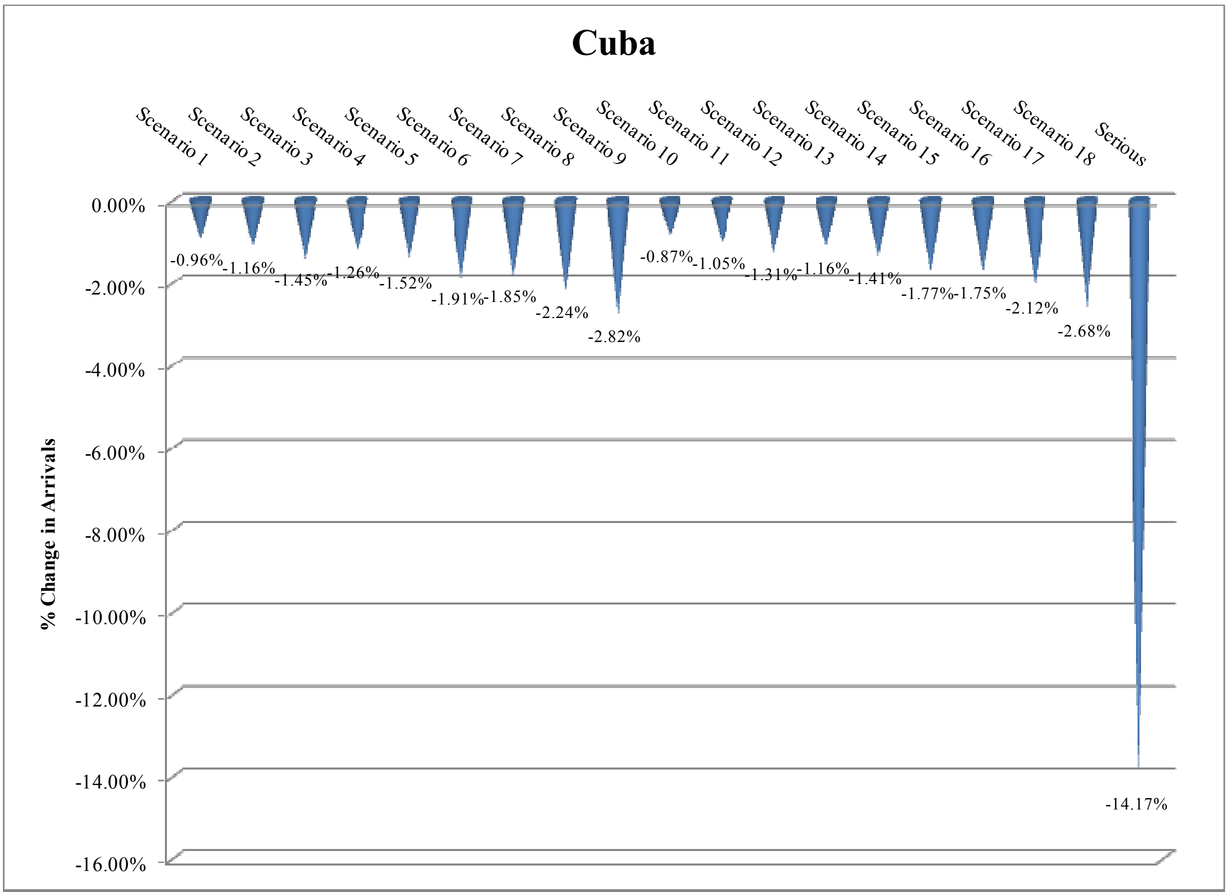
Scenario 16
Scenario 17
BAU 2020
Scenario 18
0.00%
-5.00%
-10.00%
-15.00%
-20.00%
-25.00%
-30.00%
% Change in Arrivals
-1.61%
-1.85%
-2.16%
-2.26%
-2.60%
-3.04%
-3.56%
-4.09%
-4.79%
-1.48%
-1.70%
-1.99%
-2.13%
-2.44%
-2.86%
-3.43%
-3.94%
-4.61%
-28.75%


Cuba
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Scenario 18
Serious
% Change in Arrivals
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-0.96%
-1.16%
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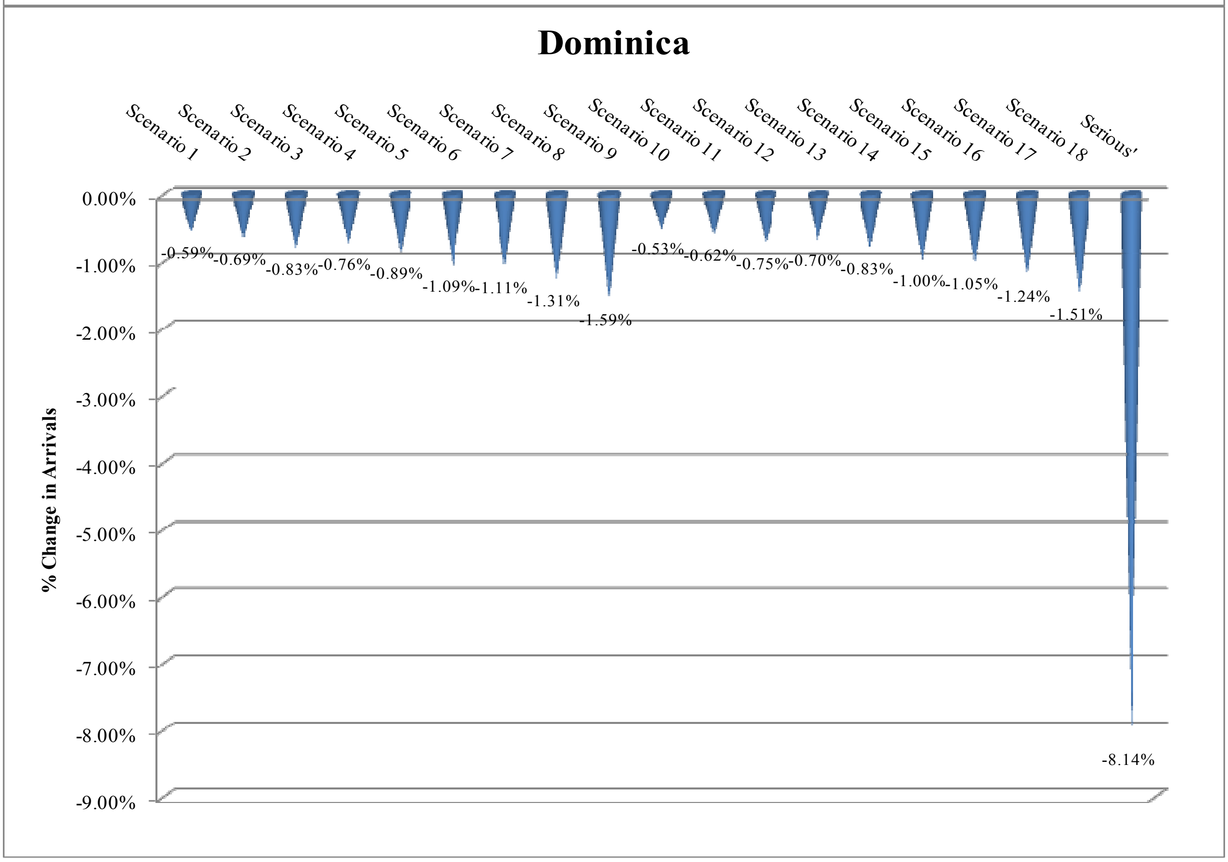
-1.26%
-1.52%
-1.91%
-1.85%
-2.24%
-2.82%
-0.87%
-1.05%
-1.31%
-1.16%
-1.41%
-1.77%
-1.75%
-2.12%
-2.68%
-14.17%


Dominica
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-0.69%
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-0.76%
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-1.09%
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-1.59%
-0.53%
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-1.24%
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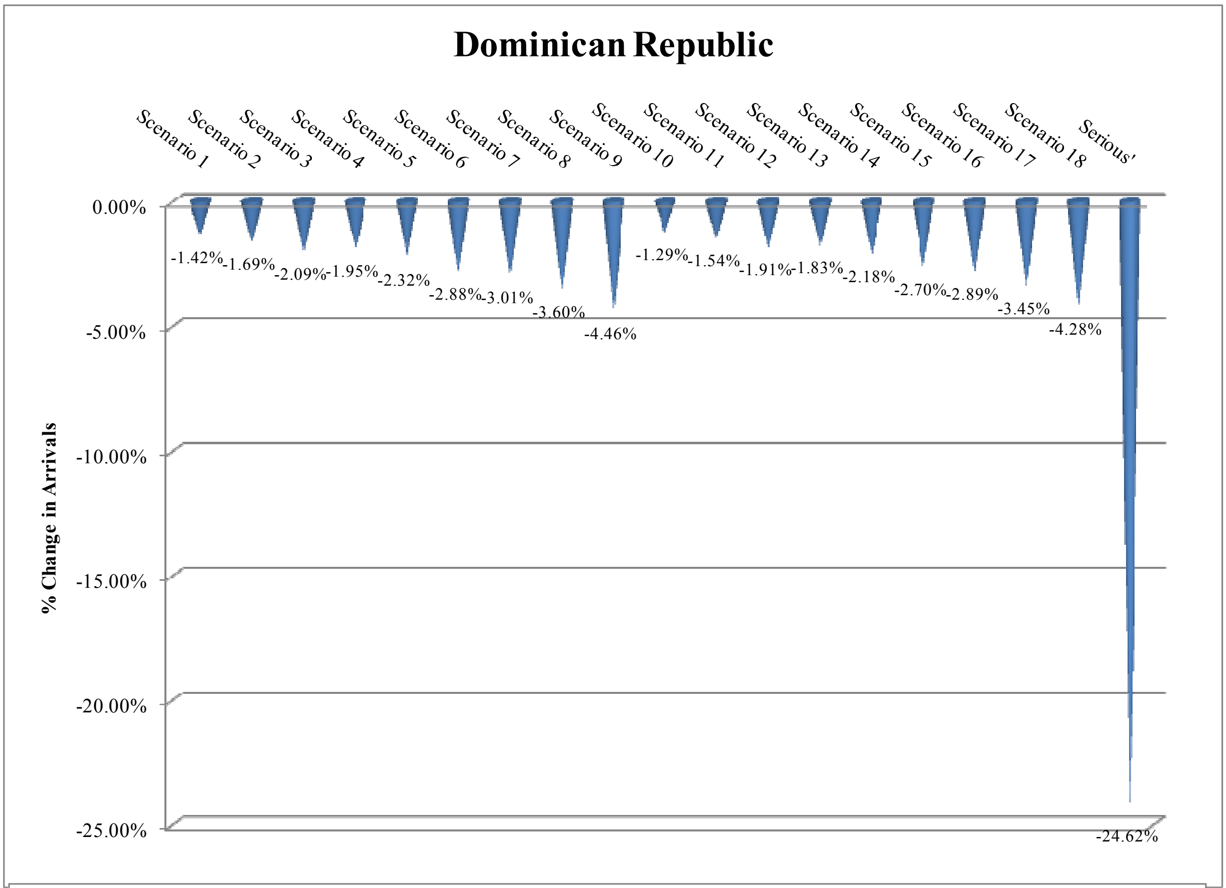

Dominican Republic
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Serious'
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-25.00%
% Change in Arrivals
-1.42%
-1.69%
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-1.95%
-2.32%
-2.88%
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-3.60%
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-1.54%
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-1.83%
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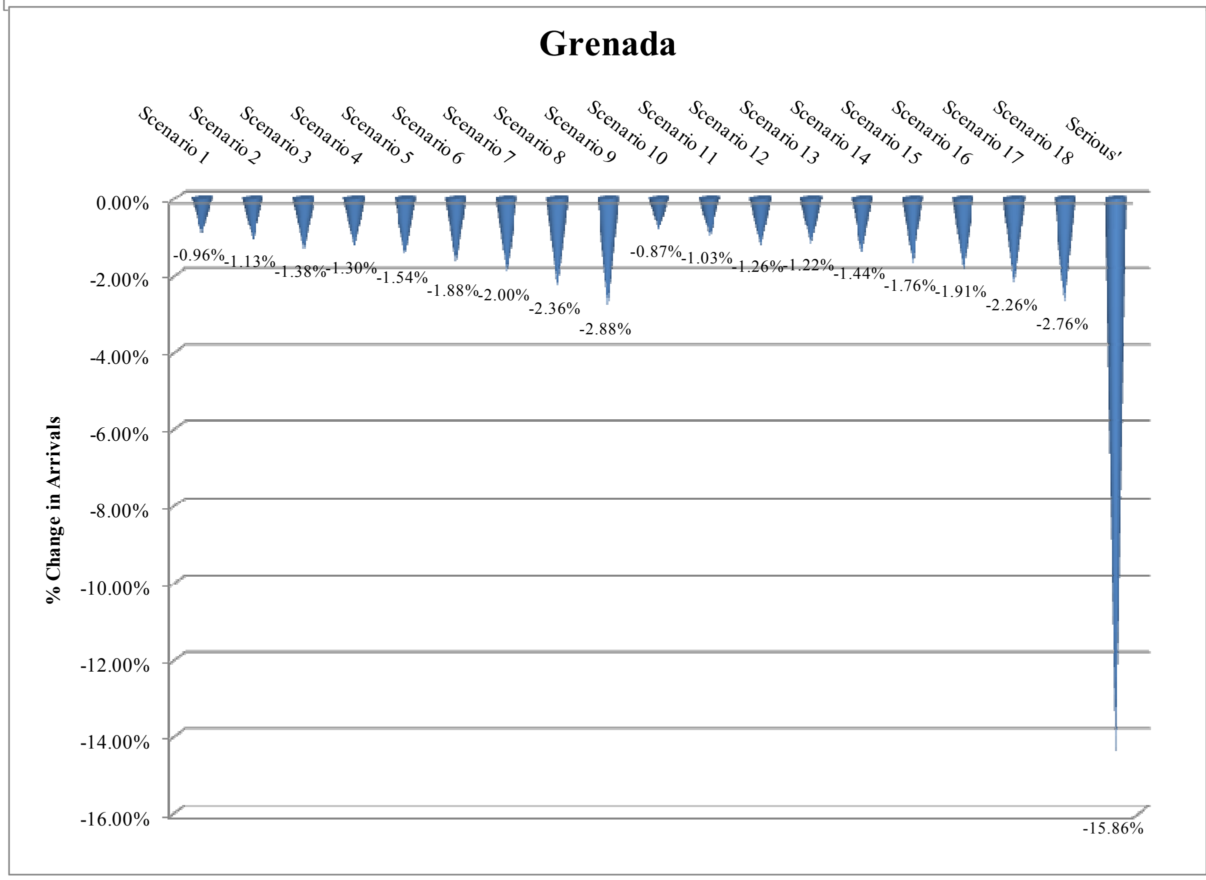
-2.70%
-2.89%
-3.45%
-4.28%
-24.62%



Grenada
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Scenario 18
Serious'
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-8.00%
-10.00%
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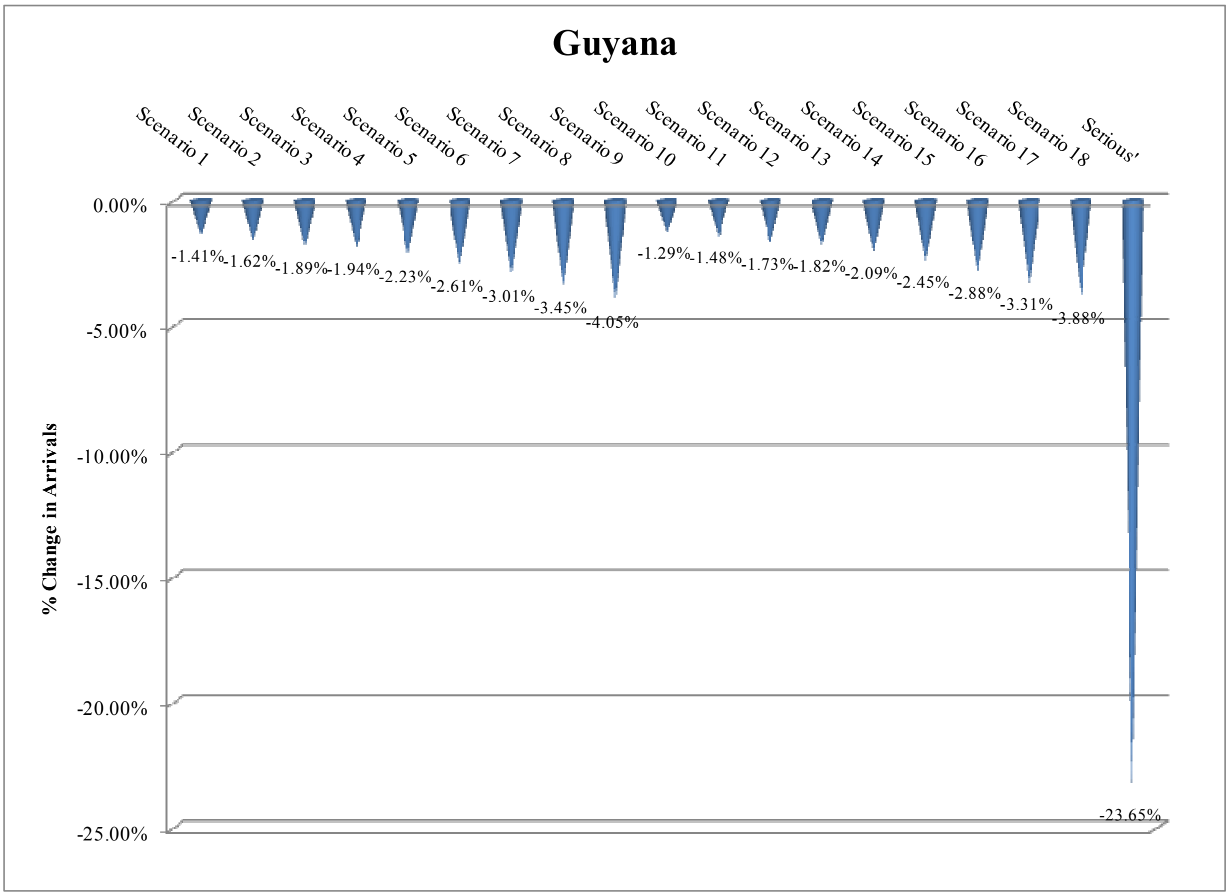
-14.00%
-16.00%
% Change in Arrivals
-0.96%
-1.13%
-1.38%
-1.30%
-1.54%
-1.88%
-2.00%
-2.36%
-2.88%
-0.87%
-1.03%
-1.26%
-1.22%
-1.44%
-1.76%
-1.91%
-2.26%
-2.76%
-15.86%


Guyana
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Scenario 18
Serious'
% Change in Arrivals
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-3.88%
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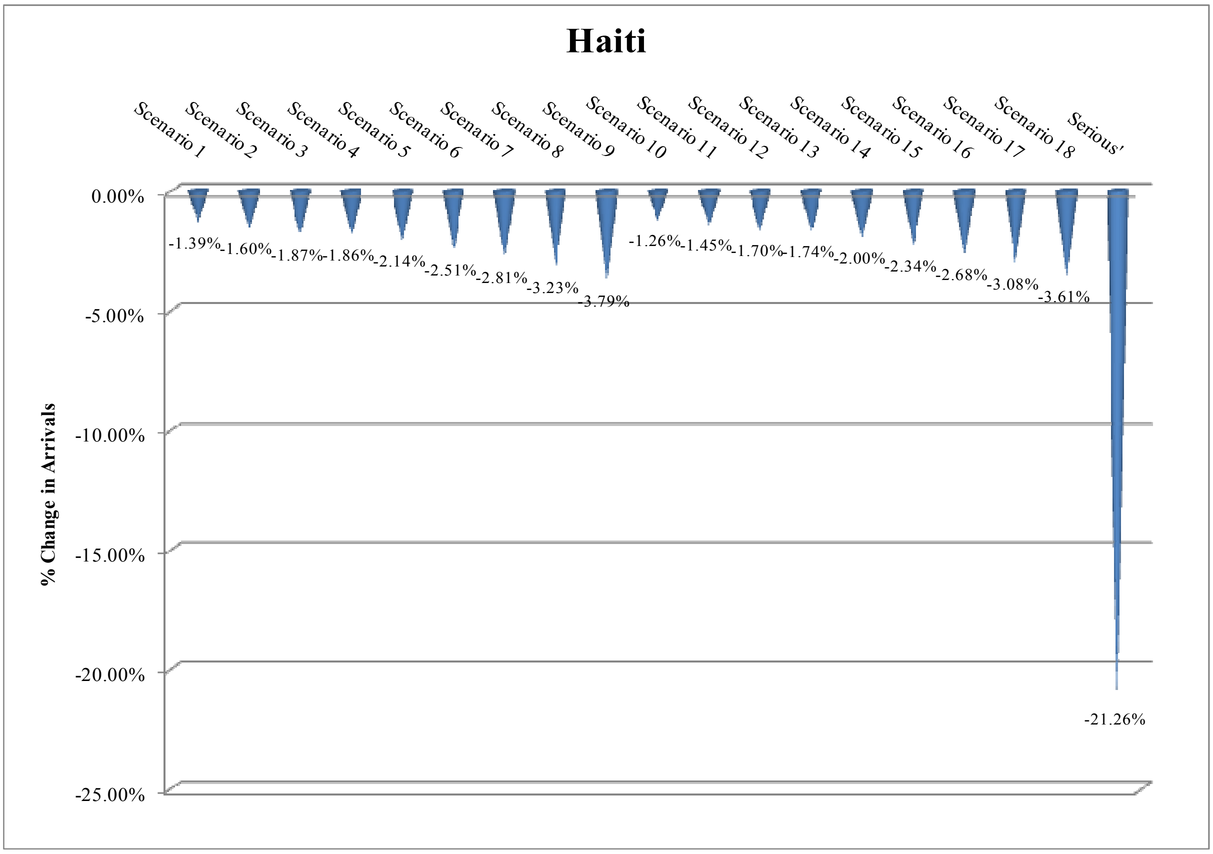
Haiti
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Scenario 18
Serious'
% Change in Arrivals
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-1.39%
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-1.87%
-1.86%
-2.14%
-2.51%
-2.81%
-3.23%
-3.79%
-1.26%
-1.45%
-1.70%
-1.74%
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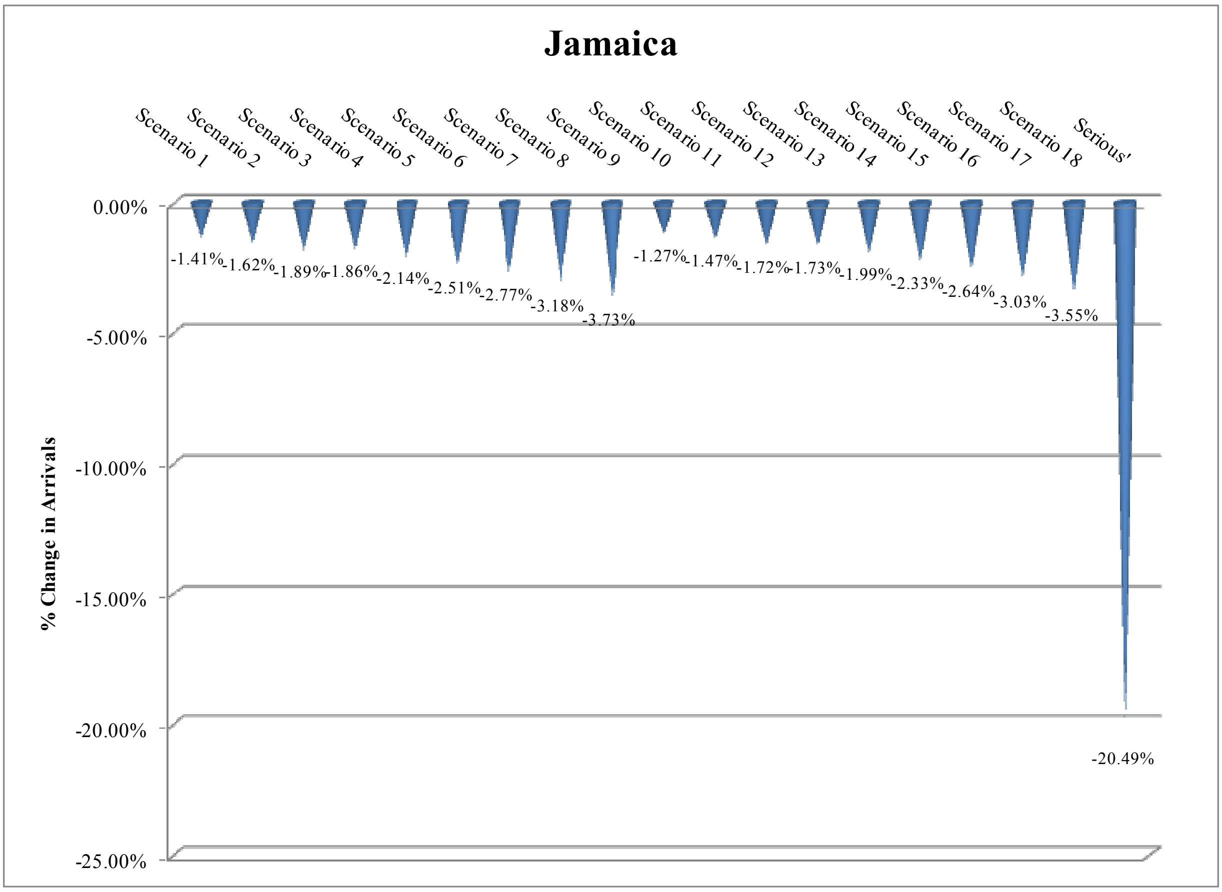
-2.34%
-2.68%
-3.08%
-3.61%
-21.26%



Jamaica
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Scenario 18
Serious'
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-15.00%
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-25.00%
% Change in Arrivals
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-1.62%
-1.89%
-1.86%
-2.14%
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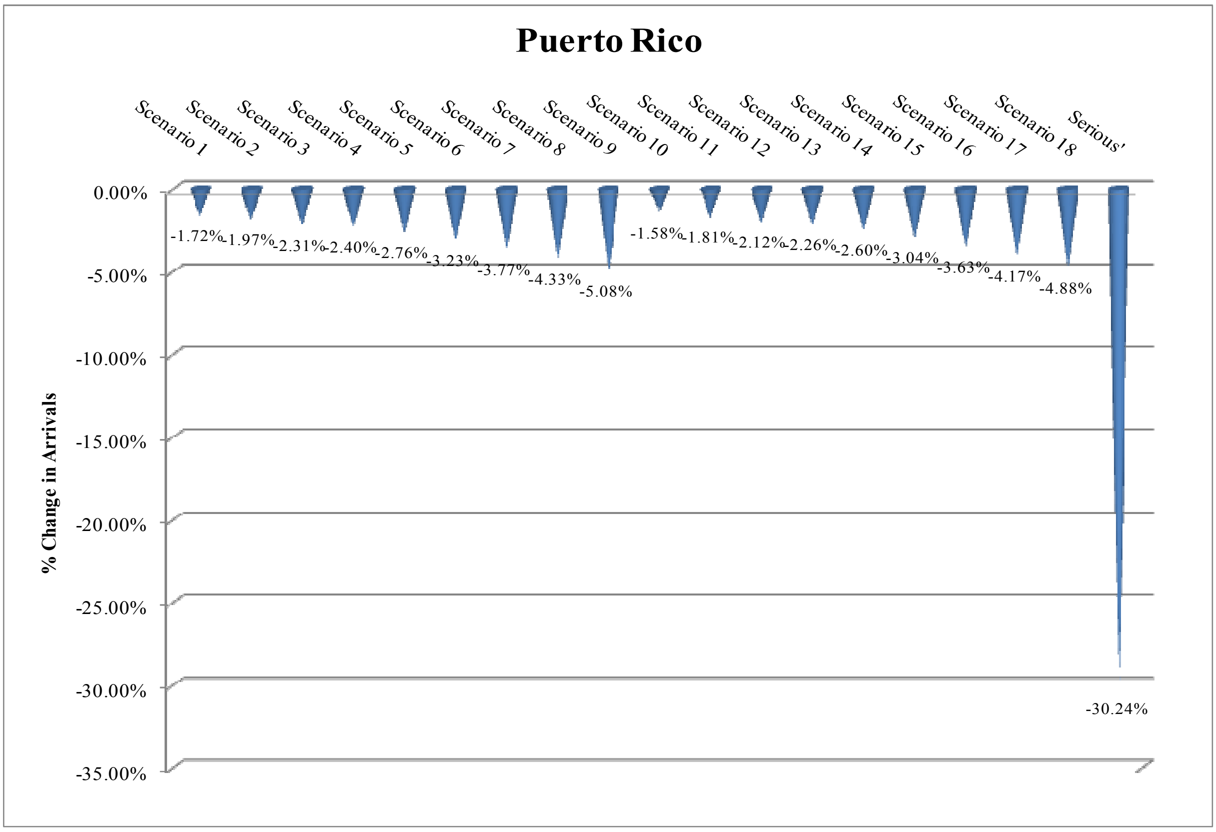
-2.77%
-3.18%
-3.73%
-1.27%
-1.47%
-1.72%
-1.73%
-1.99%
-2.33%
-2.64%
-3.03%
-3.55%
-20.49%



Puerto Rico
Scenario 1
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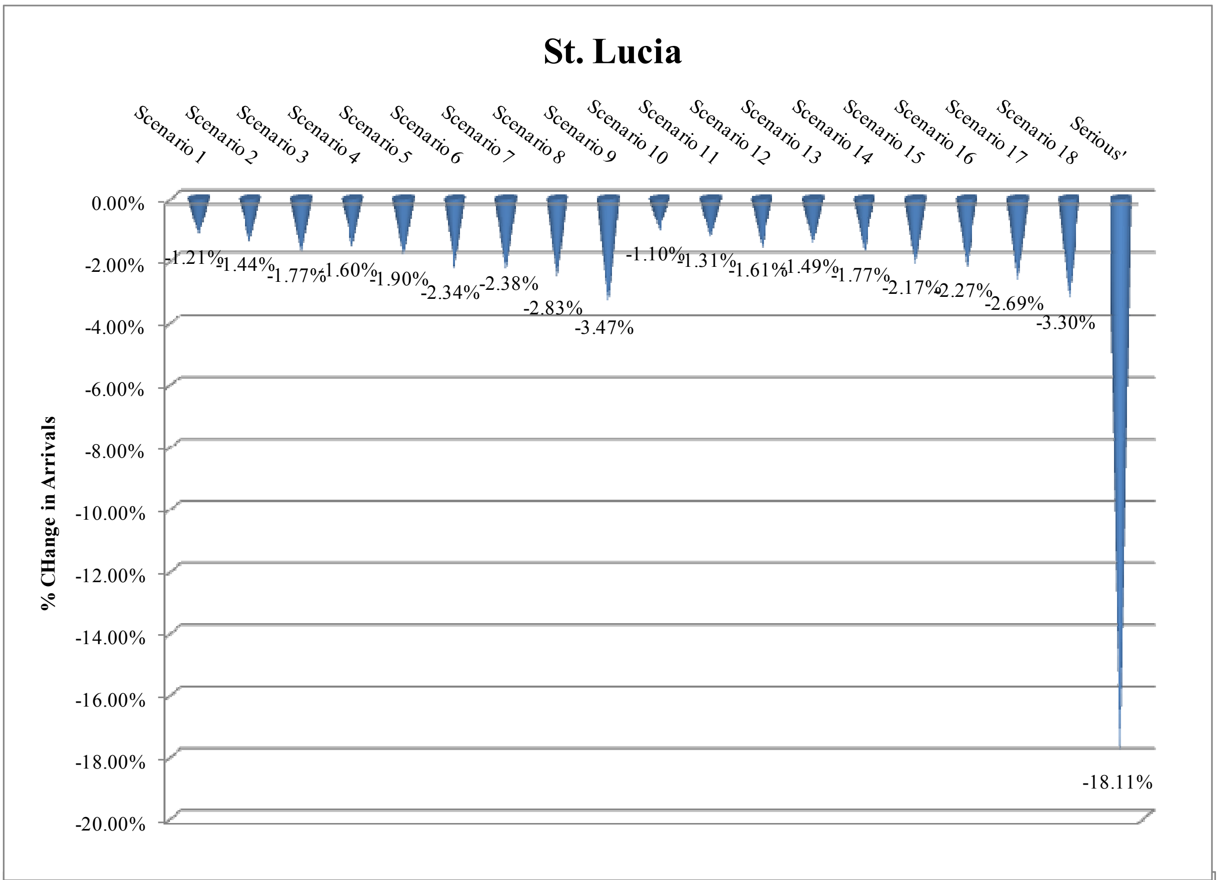
Scenario 18
Serious'
0.00%
-5.00%
-10.00%
-15.00%
-20.00%
-25.00%
-30.00%
-35.00%
% Change in Arrivals
-1.72%
-1.97%
-2.31%
-2.40%
-2.76%
-3.23%
-3.77%
-4.33%
-5.08%
-1.58%
-1.81%
-2.12%
-2.26%
-2.60%
-3.04%
-3.63%
-4.17%
-4.88%
-30.24%


St. Lucia
Scenario 1
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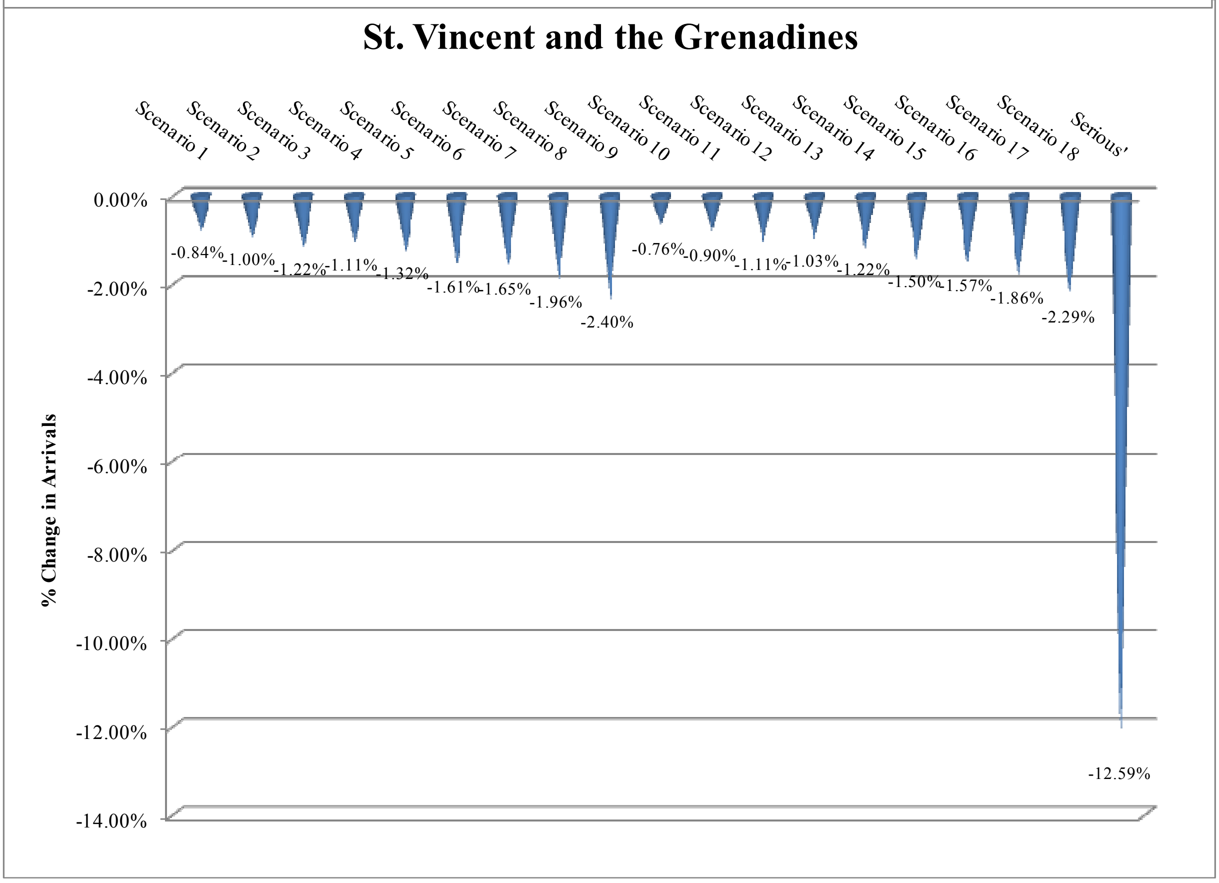
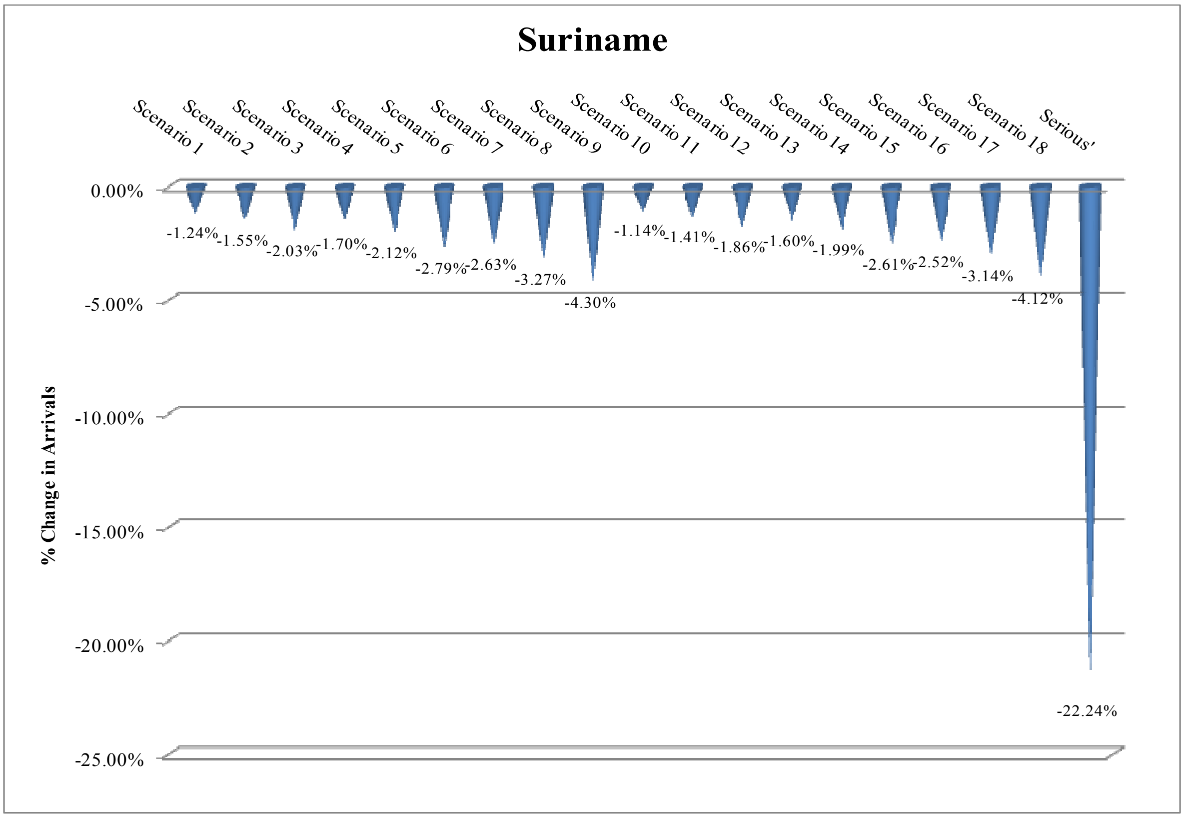
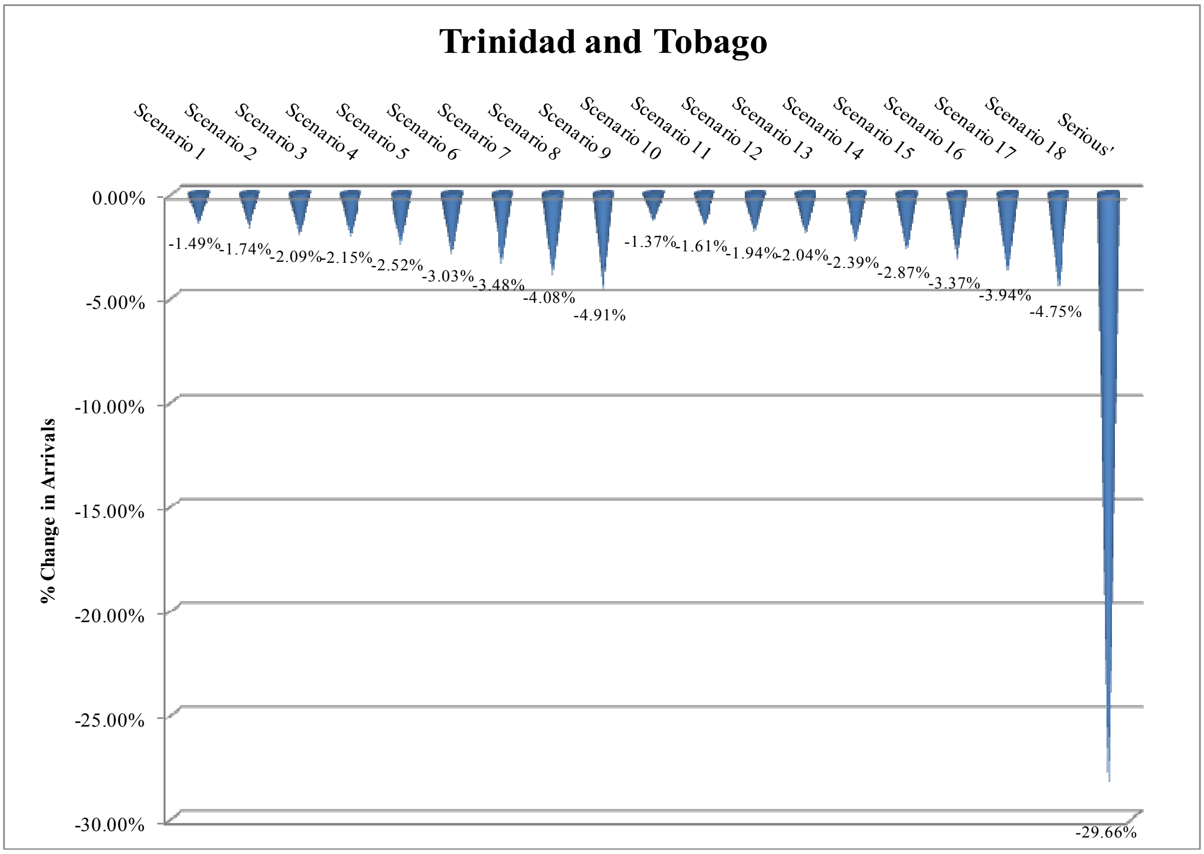
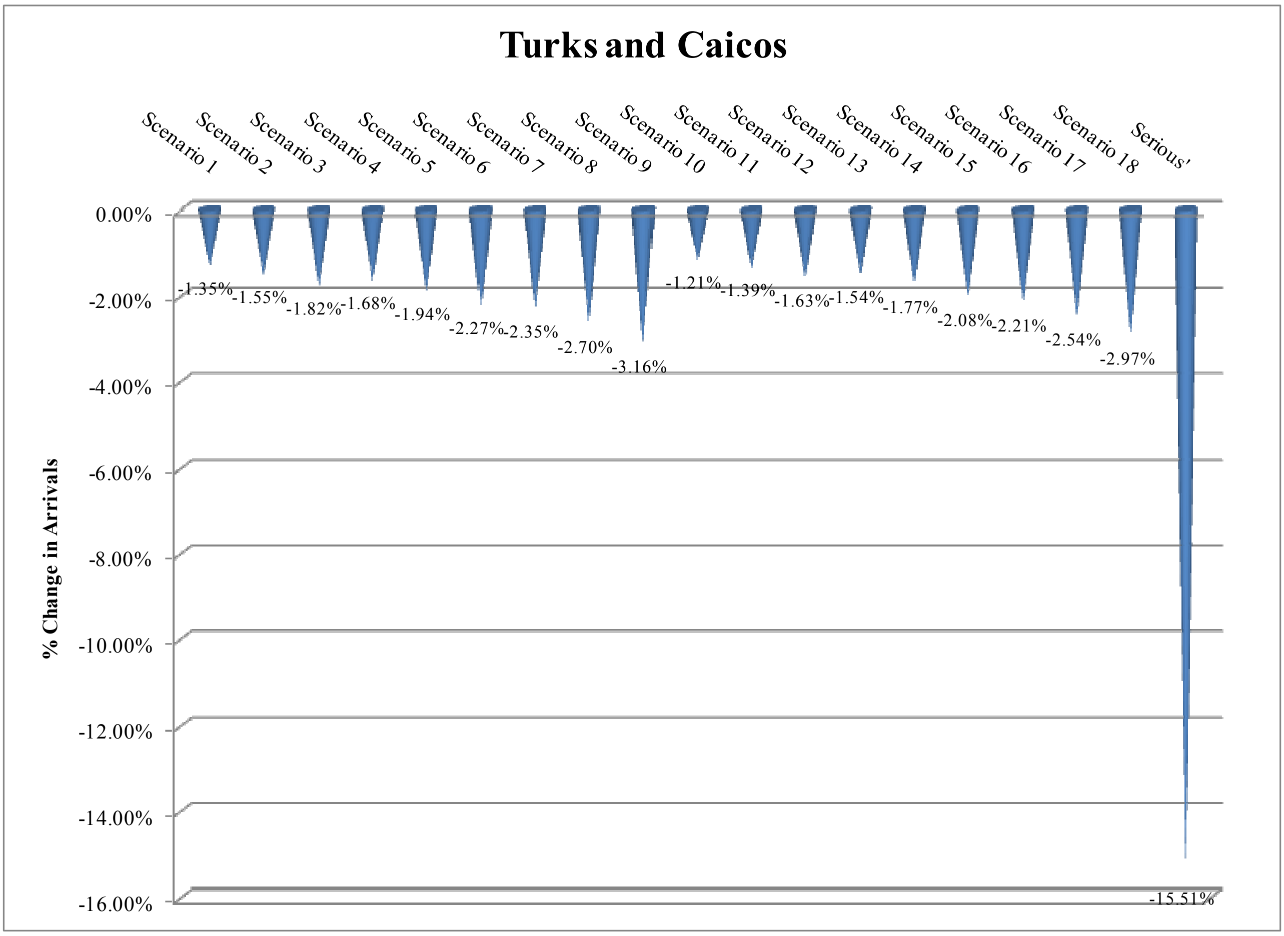
Scenario 16
Scenario 17
Scenario 18
Serious'
% CHange in Arrivals
0.00%
-2.00%
-4.00%
-6.00%
-8.00%
-10.00%
-12.00%
-14.00%
-16.00%
-18.00%
-20.00%
-1.21%
-1.44%
-1.77%
-1.60%
-1.90%
-2.34%
-2.38%
-2.83%
-3.47%
-1.10%
-1.31%
-1.61%
-1.49%
-1.77%
-2.17%
-2.27%
-2.69%
-3.30%
-18.11%


St. Vincent and the Grenadines
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 8
Scenario 9
Scenario 10
Scenario 11
Scenario 12
Scenario 13
Scenario 14
Scenario 15
Scenario 16
Scenario 17
Scenario 18
Serious'
% Change in Arrivals
0.00%
-2.00%
-4.00%
-6.00%
-8.00%
-10.00%
-12.00%
-14.00%
-0.84%
-1.00%
-1.22%
-1.11%
-1.32%
-1.61%
-1.65%
-1.96%
-2.40%
-0.76%
-0.90%
-1.11%
-1.03%
-1.22%
-1.50%
-1.57%
-1.86%
-2.29%
-12.59%


Suriname
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 8
Scenario 9
Scenario 10
Scenario 11
Scenario 12
Scenario 13
Scenario 14
Scenario 15
Scenario 16
Scenario 17
Scenario 18
Serious'
% Change in Arrivals
0.00%
-5.00%
-10.00%
-15.00%
-20.00%
-25.00%
-1.24%
-1.55%
-2.03%
-1.70%
-2.12%
-2.79%
-2.63%
-3.27%
-4.30%
-1.14%
-1.41%
-1.86%
-1.60%
-1.99%
-2.61%
-2.52%
-3.14%
-4.12%
-22.24%


Trinidad and Tobago
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 8
Scenario 9
Scenario 10
Scenario 11
Scenario 12
Scenario 13
Scenario 14
Scenario 15
Scenario 16
Scenario 17
Scenario 18
Serious'
% Change in Arrivals
0.00%
-5.00%
-10.00%
-15.00%
-20.00%
-25.00%
-30.00%
-1.49%
-1.74%
-2.09%
-2.15%
-2.52%
-3.03%
-3.48%
-4.08%
-4.91%
-1.37%
-1.61%
-1.94%
-2.04%
-2.39%
-2.87%
-3.37%
-3.94%
-4.75%
-29.66%


Turks and Caicos
% Change in Arrivals
0.00%
-2.00%
-4.00%
-6.00%
-8.00%
-10.00%
-12.00%
-14.00%
-16.00%
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 8
Scenario 9
Scenario 10
Scenario 11
Scenario 12
Scenario 13
Scenario 14
Scenario 15
Scenario 16
Scenario 17
Scenario 18
Serious'
-1.35%
-1.55%
-1.82%
-1.68%
-1.94%
-2.27%
-2.35%
-2.70%
-3.16%
-1.21%
-1.39%
-1.63%
-1.54%
-1.77%
-2.08%
-2.21%
-2.54%
-2.97%
-15.51%

Appendix B: Origin-Destination Data

(Price of Flight, Distance, Emissions, Percentage of Total Arrivals)

Origin-Destination Pair	Cost of a Round Trip Flight (February 7-14, 2009) 2008 USD	Distance Between Origin-Destination (km)	Emissions Between Origin-Destination (tonnes of CO_2)	Percentage of Total Arrivals
ANG-USA	$790.68	2746	0.688	67.22
ANT/BAR-USA	$601.41	2918	0.552	27.91
ANT/BAR-UK	$1,307.98	619	1.3117	37.93
BAH-USA	$349.44	1819	0.6	85.82
BAR-USA	$608.85	3421	0.856	29.93
BAR-UK	$1,208.91	6810	1.478	36.79
BAR-CDN	$584.86	3965	0.883	8.71
BEL-USA	$322.38	2975	0.626	61.71
BER-USA	$539.01	1278	0.303	75.67
BVI-USA	$539.01	2673	0.476	56.74
BVI-UK	$1,157.56	6688	1.237	6.93
CAY-USA	$417.64	2535	0.576	70.82
CUB-CDN	$792.96	2365	0.4	25.97
CUB-UK	$1,030.55	7540	1.398	8.6
CUB-SPA	$1,093.81	7960	1.3	8.37
CUB-ITA	$1,028.61	8751	1.423	7.3
DOM-USA	$766.77	3094	0.57	23.33
DOM-UK	$1,154.57	6716	1.331	7.72
DR-USA	$420.27	2546	0.42	26.74
DR-CDN	$516.83	3002	0.664	11.62
DR-FRA	$870.52	7258	1.227	8.23
DR-SPA	$888.72	7238	1.118	6.9
DR-GER	$903.18	7689	1.299	6.32
DR-UK	$855.94	7055	1.282	6.01
GRE-USA	$541.53	3444	0.647	25.55
GRE-UK	$1,399.74	7049	1.538	15.83
GRE-CDN	$726.97	3969	0.7	4.4
GUY-USA	$686.13	4126	0.8133	51.52
GUY-CDN	$620.59	4660	0.86	13.62
HAI-USA	$400.34	2509	0.415	68.63
JAM-USA	$445.56	2594	0.424	71.66
PR-USA	$313.24	2630	0.419	76.74
STL-USA	$769.47	3293	0.825	35.4
STL-UK	$1,867.68	6848	1.458	26.65
STV-USA	$719.51	3330	0.621	28.43
STV-UK	$1,406.78	6919	1.564	14.6

SUR-NETH	$1,048.42	7549	1.261	58.39
T&T-USA	$484.47	3600	0.83	36.27
T&T-UK	$912.78	7154	1.445	14.56
T&T-CDN	$508.91	4122	0.692	10.3
T&C-USA	$628.39	2156	0.405	77.4

Appendix C: Detailed Model Diagram

Ticket cost (with increase from ETS carbon cost) = Original (2008) cost of a ticket X 1+ Percentage Increase in ticket cost from carbon allowances needed

Percentage Change in ticket cost from oil = Annual percentage change in oil prices X 0.3 (percentage of operating cost of a flight which fuel accounts for)

Percentage Increase in ticket cost from carbon allowances needed = (Tonne(s) of Carbon Above ETS Cap X Cost of a tonne of carbon on the open market) + (Tonne(s) of Carbon within 15% beneath ETS cap X Cost of a tonne of carbon in)

Tonne(s) of Carbon Above ETS Cap = Projected Emissions (round trip origin-destination) X Percentage of Projected Regional Emissions Above ETS Cap

Tonne(s) of Carbon within 15% beneath ETS Cap = Projected Emissions (round trip origin-destination) X Percentage of Projected Regional Emissions within 15% beneath ETS Cap

Projected Emissions (round trip origin-destination) = 2009 round trip emissions between origin-destination (from ICAO calculator) - (Aviation Efficiency Factor X 2009 round trip emissions between origin-destination (from ICAO calculator))

Projected Emissions for Region = (Baseline emissions for region (either NA or EU) 100 was used for 2005 to keep calculations simple X 1+ Annual Aviation Growth Rate for Region) X Aviation Efficiency Factor

Projected Regional Emissions Above ETS Cap = Projected Emissions for Region - Emission Cap

Projected Regional Emissions within 15% beneath ETS Cap = Emission Cap X 1+0.15